an international monthly

THE Petroleum Engineer

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Drilling and Producing | Refining and Gas Processing | Oil and Gas Pipelining

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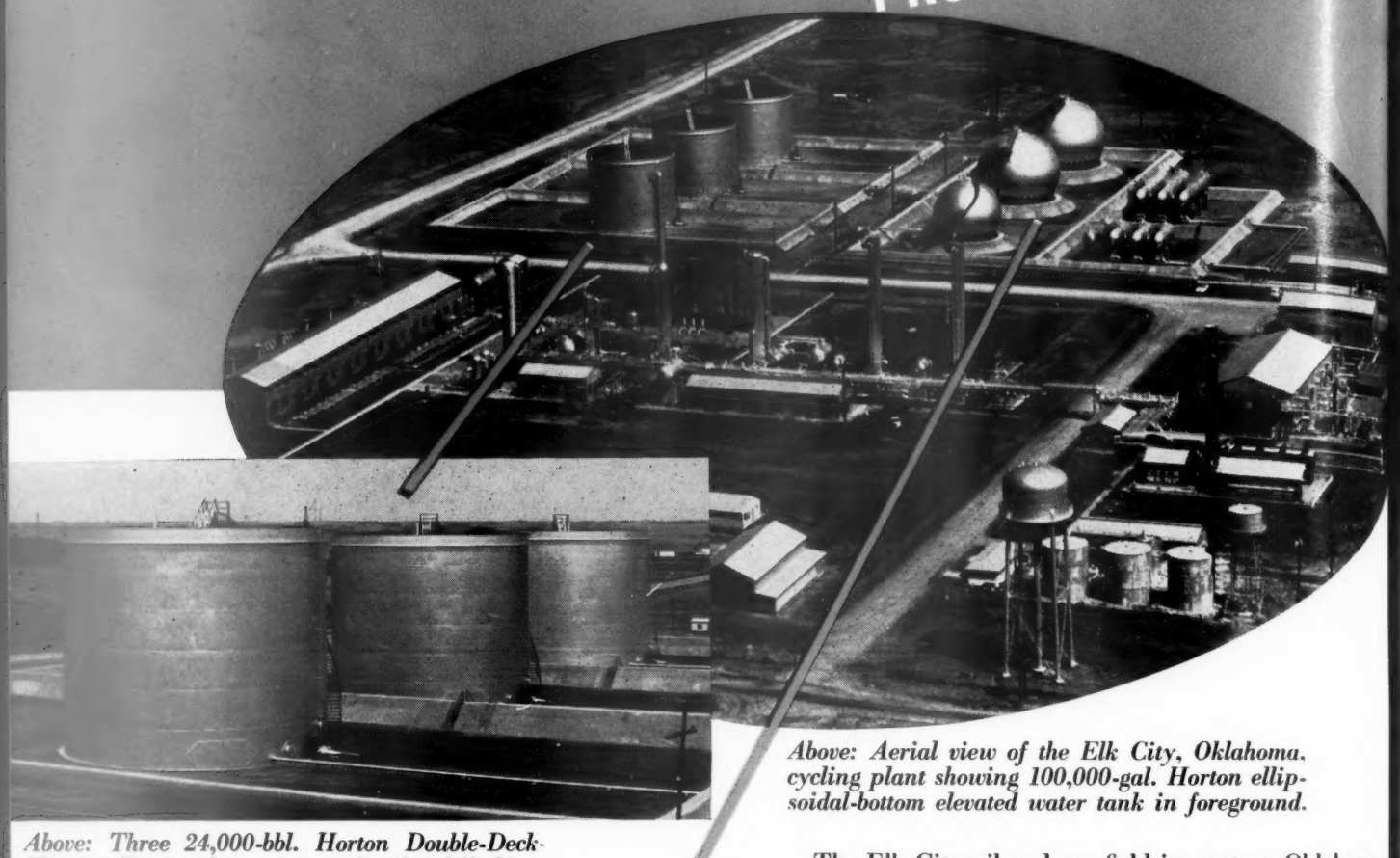
MAY 1952

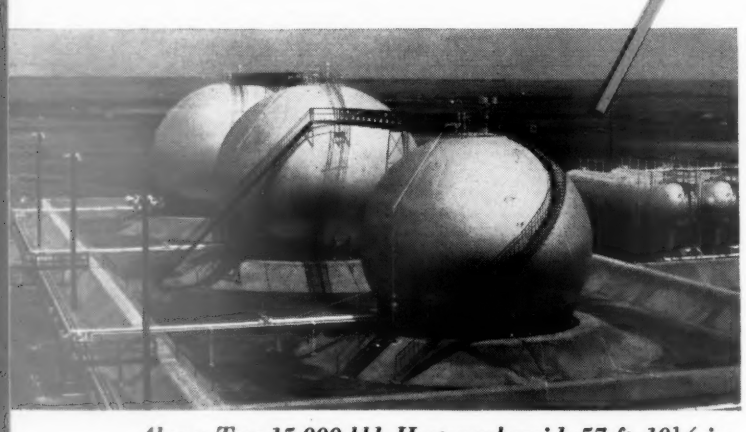
ELK CITY

Combining Modern Processing and Storage Techniques for More PROFITABLE Operation



Above: Aerial view of the Elk City, Oklahoma, cycling plant showing 100,000-gal. Horton ellipsoidal-bottom elevated water tank in foreground.

Above: Three 24,000-bbl. Horton Double-Deck Floating Roof tanks storing crude oil at Elk City.



Above: Two 15,000-bbl. Hortonspheroids 57-ft. 10⅛-in. diam. by 49-ft. 10-in. and one 7,500-bbl. Hortonspheroid 45-ft. 6-in. diam. by 40-ft. at Elk City.

The Elk City oil and gas field in western Oklahoma has been operated as a unit since Jan. 1st, 1951. An operating committee, consisting of one representative for each of the nine operators in the field, has designated the Shell Oil Company as Unit Operator. Unitization is expected to increase the ultimate production of the field by 25 per cent.

Production of both oil and gas is delivered by pipe line at 900 lbs. per sq. in. pressure directly to a cycling plant where crude oil, gas and any water in the stream are separated. The crude stream is then flashed at 285 lbs. per sq. in.; heated to 275-300 deg. Fahr.; passed through a stripper; and stored in tanks with Floating Roofs until shipped by pipe line to a refinery.

Wet gas from the separator is processed at 1100 lbs. per sq. in. in an absorption plant which recovers 225,000 gals. of natural gasoline and propane and 55,000 gals. of propane per day. Four million cu. ft. of dry gas is burned as fuel; 30 million cu. ft. sold to a pipe line; and 75 million cu. ft. returned to the producing sands at 3800 lbs. per sq. in. pressure.

Helping Elk City obtain maximum efficiency in these operations are three 24,000-bbl. Horton Double-Deck Floating Roof tanks, one 7,500-bbl. and two 15,000-bbl. Hortonspheroids, one 72-in. diam. by 14-ft. gas separator, a 10,000-bbl. flat-bottom water tank and a 100,000-gal. Horton elevated water tank.

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ARE WE RUNNING OUT OF OIL?

LAST month the American Association of Petroleum Geologists, the Society of Exploration Geophysicists, and the Society of Economic Paleontologists held their annual meeting in Los Angeles. Among this group optimistic views were expressed regarding the future of oil discovery. Indeed, the retiring president of the AAPG, Frank A. Morgan, hit out at those who would have us believe that we are running out of oil. "We have no room for that everlasting segment of industry or science," he said, "whose thesis is the scare of shortage, or the philosophy of imminent failure. Historically these people have always been wrong in their predictions about oil finding. Their philosophy often has been 'because I cannot see it or understand it, it cannot be'."

He went on to cite the many false alarms that have been raised by pessimists through the years and observed that "we witness the events of history that are so similar to the happenings of today. All the momentous events that appear on the record were influenced deeply by the actions of men. Big men with the aid of science have maintained an increasing oil and gas production and discovery in spite of those who said it could not be done." There is ample evidence to show that "in reviewing all the pessimistic forecasts and attempted controls, many have been wrong, many have failed, few contributed to getting the job done. The great balancing effect has been the result of the simple rules of private initiative with an occasional assist from the law of supply and demand.

"We cannot plan the oil field discoveries for 1952 or 1953, otherwise none of us competitors could afford to be in this room today. But in our science as contrasted with the sciences of politics and planned economy we do have the advantage of knowing that great undiscovered oil reserves inevitably exist, that our technology of oil finding works and that it will unquestionably continue to advance as it has in the past."

These are forthright statements regarding the future outlook for oil discovery, with which the industry will agree. "The business of running out of oil is an old story and I cannot understand why it is brought up so often by thinking people. I can see less reason why these pessimistic statements should be given weight now than in the many, many times in the past. They have always been wrong for the reason that they have failed to give due weight to enterprise, determination, responsibility, and an ever-increasing technology."

As if to support these observations is the fact that the increase in the nation's proved reserves during 1951 was 5 billion barrels, the greatest annual increase ever recorded. Domestic proved reserves are now more than 32 billion barrels. Are we running out of oil? These figures belie the wails of the pessimist.—K. C. S.

Control

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Same thing applies to cement: The Burner, for example, with his long years of experience, has the most modern devices at his finger tips, to *control* his operation and assure the production of cements with the uniformly high quality that means trustworthy performance... cements that produce trouble free cementing jobs when the casing is swung into place.

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...PUMP HEAVY CRUDE

at Union Oil Company's Antelope Station near Avenal, California

THE PROBLEM confronting the pipe-line engineers of Union Oil Company in modernizing the company's Antelope Station and replacing the steam pumping equipment previously in service was:

1—**to pump 15-16 gravity crude oil through an 8-inch line in varying quantities to meet**

2—**flexible requirements which might vary from 9,600 to 25,920 barrels per day.**

THE SOLUTION was the installation of "Oilwell" No. 558-P heavy-duty quintuplex plunger pipe-line pumps, driven by diesel engines through suitable reduction gears. Each pump operates independently at 103-124 RPM ranges, to deliver from 450 to 540 Bbls/h of this heavy crude at 800 PSIG. The crude is heated to 180°F. before pumping. The installation consists of three pump-engine hook-ups, with two pumps operating and the third as a standby.

ASK YOUR "OILWELL" REPRESENTATIVE to show you how the design of these quintuplex pumps makes them exceptionally suitable for pumping either heavy or volatile products . . . and get your copy of the new "Oilwell" Pipe Line Pump Booklet—No. 13-51.

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With the EDITORS . . . . . .

Cost of Building Pipe Lines—

"Pipe line companies are facing sharp rises in operating and construction costs. New pipe line systems are stretching across the nation, farther and farther from the source of supply. Costs of delivering gas increase in direct proportion to the distance fuel is transported. The cost of constructing pipe lines has increased more than 85 per cent during the past 10 years. Companies that figured an average cost of $1000 per inch mile for pipe line construction in 1941, now have to estimate between $1850 and $2500 per inch mile for similar lines."

These words were contained in a speech written by George F. Mitchell, president of the American Gas Association, and president of the Peoples Gas Light and Coke Company of Chicago, to be delivered before the New England Gas Association in Boston. The day before his scheduled appearance, however, Mr. Mitchell died and his speech was read by Earl H. Eacker, vice president of AGA. His words point up, in view of the many thousands of miles of pipe lines laid during the last decade, the enormity of the pipe line structure and the vastness of the investment required to keep pace with ever-increasing consumer demand.—F.H.L.

Engineers in Management

As private business grows larger and more complex in organization, it takes on some of the characteristics of the Federal Government, that of top-heaviness, and the lack of close contact between different segments of the organization. For any size organization, however, the private outfit always has a much closer liaison between its parts than has a governmental group of the same approximate size, a matter again of individual responsibility, individual authority, the push of personal ambition and energy.

Recently in a Professional Engineers' survey it was found that chief engineers are very important people, and take part in company planning more than do those titled vice presidents of engineering. Engineers below that rank participate largely in new products and processes, engineering problems, and employee training, but to a greatly lessened degree in other matters. Therefore the problem arises as to how to keep the engineering staff informed. The supervisory channel in the organization is usually that followed by management in transmitting information through the engineering staff. In fact one top executive said, "It's up to supervision to keep engineers informed; just send the word down the line." Of the large number of companies taking part in the survey, from more than 100 industries, 88 per cent make effort to find out the ideas and suggestions of their engineers on company matters; those who do not are small, employing 25 engineers or a less number. When asked if engineers are told why a business action has been taken involving engineering projects or products, 96 per cent said that they are told, via the supervision channel. Unionization of engineers has shown either no effect on communication or an adverse effect in the huge majority of cases. Significantly enough, not only are a greater number of engineers showing up in executive ranks, but most companies have a "more than ordinary interest" in their engineers as potential future managers.

And one of the main difficulties in getting engineers' ideas up to management is the authoritarian attitude of management personnel, the "impatience with subordinates and what they are saying" complex shown by superiors. "Listening and acting on the basis of what subordinates think, not what we think, is absolutely essential to realistic management," is one main conclusion drawn from this investigation.—A. L. F.

Widespread Gas Use—

A preliminary report, released by the U.S. Bureau of Mines, discloses that 7,415,600,000,000 (trillion) cu ft of natural gas were produced for marketing in 1951. This total includes 87,800,000,000 cu ft in exports, lost in transmission, and unaccounted for. Consumption was divided as follows: Residential, 1,471,100,000,000 cu ft; commercial, 445,900,000,000 cu ft; industrial, 3,495,400,000,000 cu ft; field, 1,364,800,000,000 cu ft, and carbon black, 422,200,000,000 cu ft. Additionally, 128,400,000,000 cu ft were stored during the year.

The total marketed consumption for the year exceeded the 1950 figure by 18 per cent, the Bureau said, with consumption in the Middle Atlantic states increasing by 55 per cent.

Appropriately, in view of the gas industry's steady growth, the theme of the Spring Conference of the Natural Gas Department of the American Gas Association in Los Angeles will be along the lines of future plans and prospects. It is quite generally agreed that, great as it already is, the nation's natural gas system has just begun to expand. Existing markets are increasing constantly and many new markets are being opened. The industry has allocated $3,000,000,000 for new plant and facilities in the next four years.

Speakers will highlight this progress and its significance. Considered in like measure will be the AGA research program, which progressively is being given greater attention.—F.H.L.

Lightning Analyzer-Calculator

By combining a mass spectrometer and an electronic counter, Physical Research Laboratories has made up a "robot brain" that operates at the rate of 100,000 digits per second, its inventors say, which is accredited as being 10,000 times as fast as any human being can work. Report says this unit can analyze a trace of a fluid and make out a typewritten report of the complete chemical analysis, all in a matter of a few minutes. Its name is Miniac and it was developed for Atlantic Refining Company. An important item in the assembly in a "selector" designed by Consolidated Engineering to associate the two main units.

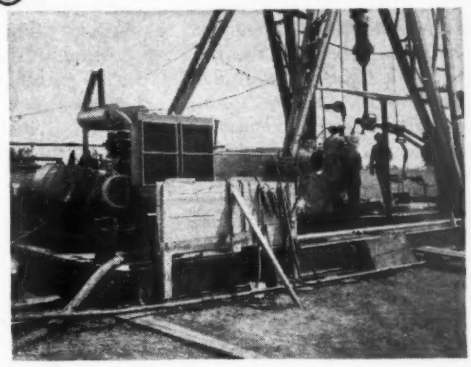
This Miniac unit sounds like a definite step forward, and we are not saying a word about the nickname it probably will receive from those who will work with it!—A. L. F.

GM Diesel
Case History No. 517-28

USER: T. M. Pruett, Centralia, Ill.

INSTALLATION: Two GM "Twin 6" Diesels, installed January, 1949, powering Unit U15 Drawworks and an A10 Emsco triplex mud pump.

PERFORMANCE: Owner reports this rig completed a round trip at 3,800 feet in 1 hour and 15 minutes, setting back doubles. It drilled 4,000 feet in 14 days through McCluskey, Devonian and Trenton formations (a good record for rigs in this area). In Frogtown area rig drilled 2,200 feet to Devonian in 4 days, 6 hours.



This Diesel made 3800-foot round trip in 75 minutes

"I switched to GM Diesels in 1947 for one good reason—they make more money for me," says T. M. Pruett, who has been drilling in the Tri-State area since 1938. "They make faster connections and round trips—cost us less to operate and are easier to service and maintain." General Motors Diesels enable drillers to get on bottom quicker and make faster round trips because of their fast-stepping 2-cycle operation. These power-packed units fit within road width, which makes them easier to move. Parts and accessories are readily accessible, and expert GM Diesel service assistance is never far away.

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SINGLE ENGINES...32 to 275 H. P. MULTIPLE UNITS...Up to 800 H. P.

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HIGHLIGHTS IN OILDOM

RUSSIANS BUY OIL PUMPS

A $6,440,000 order mysteriously placed by Russian authorities in eastern Germany for 3500 "oil pressure pumps" is being investigated by British intelligence agents. These pumps are to be used in Iran, according to German intelligence operatives. It is reported that the pumps are being delivered by four western German firms, which are being paid by the Russians in dollars, and in cash. British intelligence reports that 450 pumps, as a first installment, are due to leave Rotterdam for the Iranian port of Bushire.

ELK HILLS OPENING REJECTED

A suggestion that more crude oil be produced temporarily from the Elk Hills naval reserve has been rejected by the Munitions Board, a government official has disclosed. Petroleum Administration for Defense made the proposal as one method of increasing West Coast crude production. This would permit California refineries to turn out more residual oil, aviation gasoline, and other products like the defense department would like to get in that area.

OIL MAN IS KNIGHT

Alfred Jacobsen, president of Amerada Petroleum Corporation, is now a knight of Denmark. H. M. King Frederik IX of Denmark has conferred the Knight Cross of the Order of Dannebrog upon Jacobsen in recognition of distinguished services in promoting cultural and commercial relations between the U. S. and Denmark. Presentation was made by Ambassador Henrik Kauffmann at a private luncheon in the ambassador's home in Washington.

GUATEMALA OIL LAW STUDIED

A detailed study will be made of Guatemala's laws governing exploration for oil and exploitation of oil deposits, the country's new minister of economy, Roberto Fanjul has assured oil companies. He said purpose of the study will be to recommend certain changes in laws that will make exploration in Guatemala appealing to foreign companies.

Major U. S. oil firms withdrew in 1949 when certain laws were passed controlling exploration and exploitation in Guatemala. Known oil deposits in Guatemala underly the northeastern part of the country, known as Peten, bordered by Mexico and Honduras.

OIL TEST SET IN MISSOURI

Missouri's Boone and adjoining Howard counties may prove oil productive. W. H. Keasler Oil Company has announced that it will begin drilling shortly on a 5000-acre area of leased land. W. D. Settle, attorney for the firm, reported that geologic surveys "apparently are favorable enough to justify proceedings."

BY-PRODUCT SULFUR ESSENTIAL

By-product sulfur, made from petroleum, is helping to solve a world-wide shortage of sulfur, *The Lamp*, Standard Jersey publication reports. Oil refineries have become the second biggest consumers of sulfuric acid, a hydrogen-oxygen-sulfur compound, the publication states. Through technical developments, refineries have produced a source of by-product sulfur useful to other industries while drastically cutting their own consumption. By-product recovery plants produce sulfur from sour natural gas and oil by extracting their hydrogen sulfide and converting it into water vapor and sulfur.

FLOW RATES UP AFTER QUAKE

The big question in Oklahoma these days is did the earthquake and numerous tremors felt on April 9 have anything to do with increased production that week. The tremors followed the range of the buried Nemaha mountain in the heart of the Mid-Continent oil fields. For the week ending April 8, production in Oklahoma averaged 524,300 bbl daily. The following week the flow was 528,600 bbl, and the third week it was up to 531,200.

Theory of oil men is the shake loosened formations, thereby causing higher production rates.

STEEL SCRAP SUPPLY MOUNTS

Sun Oil Company reported to the American Iron and Steel Institute recently that it has reached its goal of 8000 tons of scrap in the 6-month pilot collection campaign it undertook as a guide for the rest of the petroleum industry.

Another company making progress on its scrap drive is Union Oil Company, who reported it had turned in 13,000,000 lb of scrap and other surplus material in the first six months of its campaign to help alleviate the nation's critical shortage of steel scrap.

WILLISTON BASIN SEES FIRST YEAR

The Williston Basin celebrated its first birthday recently. One year ago on March 29 Amerada Petroleum Corporation brought in its No. 1 Clarence Iverson in Williams County, North Dakota, bringing with it the attention of all the industry. This was North Dakota's first productive oil well. Amerada men gathered in Williston to celebrate North Dakota's first year as an oil state.

OIL AVAILABLE FOR FLOOD AREA

Ample supplies of oil and gasoline are assured for residents of the flood stricken Omaha, Nebraska, area, despite the possibility that the Missouri River dikes may break, Manley F. Ousley, state chairman of the Nebraska Oil Industry Information Committee reported. Although installations of numerous oil companies in this area are threatened by the flood waters and have already been evacuated, alternate sources of supplies are being used.

VENEZUELA WANTS LOW TARIFF

Venezuela is expected to ask for generous crude petroleum tariff concessions from the U. S. when the two nations open bilateral reciprocal trade talks soon. Under present trade agreement about one-third of Venezuela's petroleum comes in at 10.5 cents a barrel. The Venezuelan government wants that 10.5 applied to all its oil, or even better, have the U. S. grant the maximum concession permitted by general reciprocal trade law—5.25 cents a barrel.

ENGINEERING STUDENTS SOUGHT

Terming the shortage of engineers as the current number one problem of the U S., T. A. Marshall, Jr, executive secretary of the Engineering Manpower Commission of Engineers Joint Council said, "Every secondary school in the United States will receive a four color poster designed to help alleviate the critical shortage of engineers."

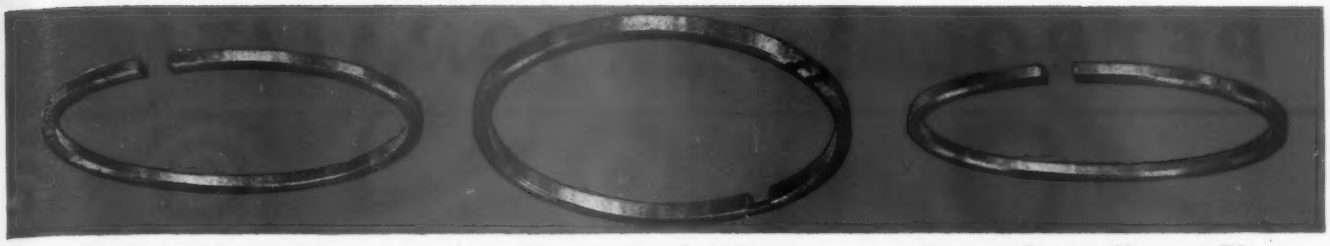
BLS REPORTS ON OIL WORKERS' WAGES

The Bureau of Labor Statistics has revealed that average straight-time earnings for key jobs in crude oil production ranged from $1.37 an hour for part-time pumpers to $2.82 for rig builders in October and November of last year.

Half the job averages fell in the $1.59 to $1.88 an hour group, the report revealed, with tool pushers and rotary drillers averaging more than $2 an hour.

Figures are:

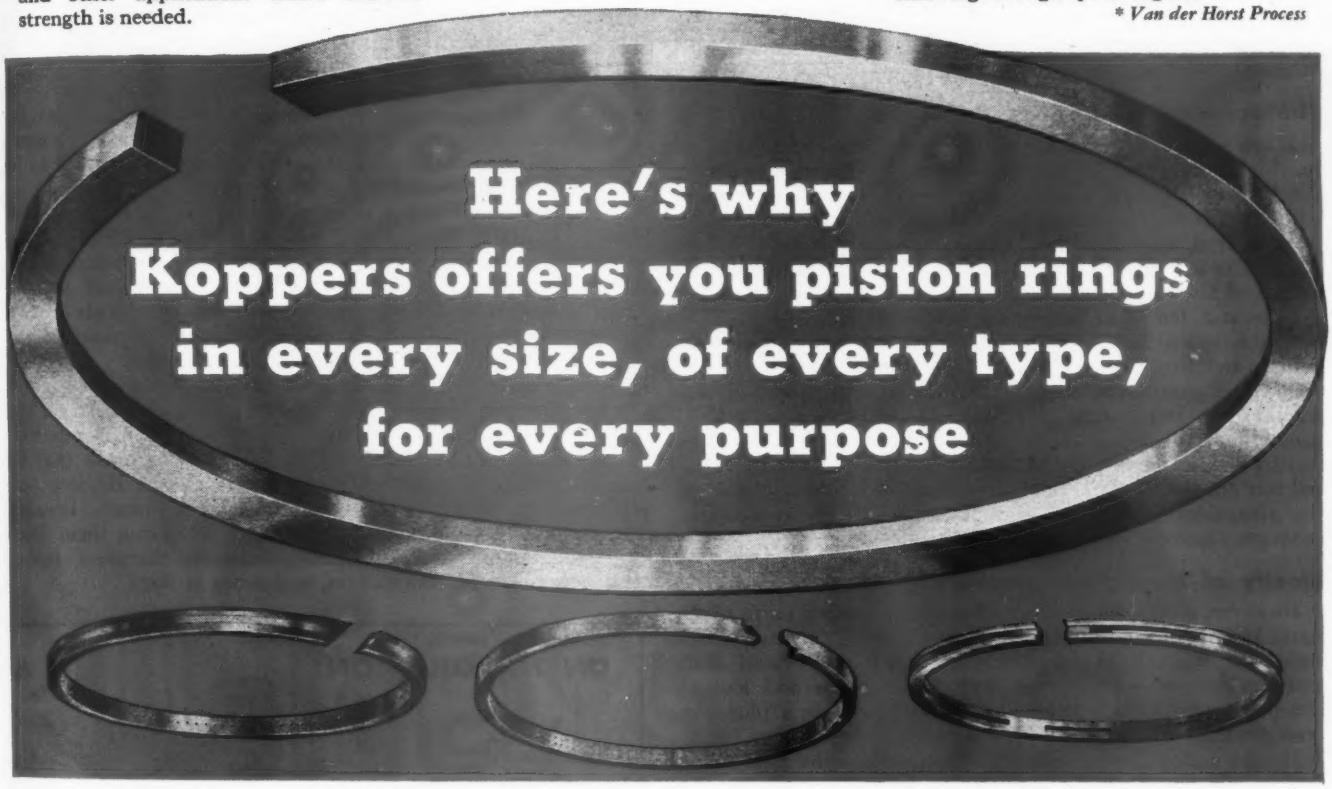
Occupation	U. S. average	Oklahoma	North Texas	East Texas	South Texas	West Texas	No. of workers nationally
Derrickmen	$1.72	$1.59	$1.62	$1.63	$1.71	$1.67	9,975
Drillers, rotary	2.20	2.11	1.97	2.18	2.20	2.17	11,033
Enginemen, rotary	1.64	1.57	1.47	1.61	1.67	1.64	5,047
Floormen, rotary	1.62	1.54	1.48	1.53	1.57	1.57	22,562
Mechanics, maintenance	1.88	1.81	1.96	1.76	1.74	1.69	2,380
Pumpers, full time	1.66	1.59	1.60	1.62	1.79	1.67	27,117
Pumpers, part time	1.37	1.12	1.08	1.80	1.80	1.52	2,447
Roustabouts	1.60	1.53	1.51	1.63	1.65	1.54	19,542
Tool pushers	2.64	2.57	2.14	2.56	2.70	2.66	3,026
Truck drivers:							
Under 1½ tons	1.59	....	....	....	1.52	1.42	573
1½ to 4 tons	1.43	1.56	1.27	1.30	1.20	1.55	1,681
Trailer type, over 4 tons	1.50	1.48	2.16	1.71	1.97	1.30	1,345
Other than trailer type over 4 tons	1.46	....	....	....	1.38	1.65	528
Welders, oil field	1.83	1.62	1.53	1.86	1.70	1.89	792



Koppers K-Spun Rings
Manufactured in diameters up to 12½" by Koppers exclusive centrifugal casting process. 100% stronger, 4 times more resistant to combustion shock than ordinary rings. Will not break in installation or for the life of the engine. For high-speed diesels and other applications where extreme strength is needed.

Koppers Lug Seal Rings
A specially designed two-piece ring for use on badly out-of-round and tapered cylinders, or on pistons with worn grooves. Maintains compression at a high level, prevents blow-by, provides highly efficient oil control.

Koppers Porous Chrome* Rings
Porous Chrome surface holds and distributes oil during break-in, quickly wears to perfect seating. Combined with K-Spun metal in sizes up to 12½" dia. Last up to 4 times as long as other rings, cut cylinder wear up to 50%. Designed for top compression rings of high-speed engines.
** Van der Horst Process*



Koppers Seal Rings
Specially designed ring with a projecting bronze band that causes a burnishing action on cylinder walls. Decreases scuffing and wear on cylinder walls of gas and diesel engines, air and refrigeration compressors and many other applications.

Koppers Step-Seal Rings
Designed especially for applications where blow-by is a serious problem. Combines the strength of a single-piece ring with the sealing qualities of a multiple-piece ring. For use on hydraulic presses and diesel and other internal combustion engines.

Koppers Oil-Cutter Rings
Exceptional oil control is attained by unique design . . . 2 bevels for riding over oil on upstroke, 2 scraping edges for taking excess oil from cylinder walls on downstroke, plus a series of wide drainage slots. For use on high-speed, 4-cycle engines.

These are a few of the hundreds of rings manufactured by Koppers.

EVERY piece of equipment presents a different piston ring problem. Koppers, with its wide variety of rings for every conceivable use, provides the solution to *all* industrial and automotive ring problems.

Our engineers, who work with you in determining the best rings for your applications, have all the facilities of the large, modern Koppers piston ring plant at their disposal . . . to supply you with the rings that will cut down-time, increase efficiency and lengthen the life of your equipment.

No matter what kind of equipment you have . . . railroad, stationary or marine diesels, aircraft or automotive engines, pumps, compressors, steam hammers, hydraulic presses . . . if it uses piston rings or sealing rings, write, wire or phone us today for experienced help with your piston ring problems. Koppers Company, Inc., Piston Ring Dept., 1595 Hamburg St., Baltimore 3, Maryland.

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PETROLIC PERSONALITIES

DICK SNEDDON

The Greeks Have a Word

At the Los Angeles chapter Nomads meeting the other evening we had a lovely time consorting in the better sense of the word with various and sundry people, particularly Dr. A. Th. Polyzoides, the U.S.C. lecturer on foreign relations whose column on world affairs appears daily in the *Los Angeles Times*. Much to our surprise, the noted Greek scholar was as human as all get out and he cavorted with the boys as easily and pleasantly as if he had been born of petrolic parents. As a matter of fact, at one time during the early part of the evening we formed an impromptu duet and sang a piece, entitled "Guadalajara" in a manner that was mighty sweet.

The Jonathan Inquisition

When we first entered that stately edifice, the Jonathan Club, in which the western Nomads hold sway, we spotted Lee Laird, the Baash-Ross biggie, lolling luxuriously in the barber chair while an intent tonsorialist did a classic job of topiary on his well covered headpiece. Lee, however, quickly stopped lolling when after a whispered consultation with the barber person we borrowed his scissors, snicked a sizable piece off the Laird left auricle and fed it to a passing beagle hound.

Upstairs we found Hi Cassiday, the McCarty Company genius, and Jim Hughes, the Lane-Wells goodwill ambassador, deep in a discussion of initiation rites. The question was whether the installation ceremony should be preceded by a probationary period in which the neophyte would prove himself worthy of membership, or he should be allowed to slip in without too much fuss. It is our guess that the consensus was for the pledgeship idea because we later heard mutterings about scourges, molten lead, branding irons, thumbscrews. . . .

Mostly of Male Haberdashery

However, it was none of our affair so we barged on in to the inner shrine and there, bless our soul, if we didn't run smack into Jack Ballagh, the former Patterson-Ballagh head man, just back from a honeymoon trip to Honolulu and looking sharper than a freshly whetted surgical lancet, in a blue-grey creation that the very last word in male haberdashery.

Hardly had we begun to fish for the details of the most recent Ballagh junket when we were rudely interrupted by that expatriated and irrepressible New Yorker, Octavius W. Morgan, Jr., now a considerable attachment of the Oil Well Manufacturing Corporation. Ox is apparently the same uninhibited individual and it is our observation that prolonged exposure to bowler hats, suede gloves, spats, walking sticks, have left him completely unsullied.

A Literary Interlude

We enjoyed very much, as we always do at these Nomad gatherings, a sort of literary interlude with Baldwin Reinhold, the latter- but by no means the lesser half of the firm of Abegg and Reinhold. "Reiny" as he used to be known is a cultured gentleman who has traveled widely and absorbed well. He speaks several languages and one merely has to talk to him for a few minutes to recognize that he spends a fairish amount of time regaling himself on what William Shakespeare described as "the dainties that are bred in books."

At any rate he is excellent company and although it doesn't happen as often as it should, when he is persuaded to mount the speaker's rostrum he can be depended upon to give a fine disquisition on the subject of his choice.

Joe Streeter Comes to Town

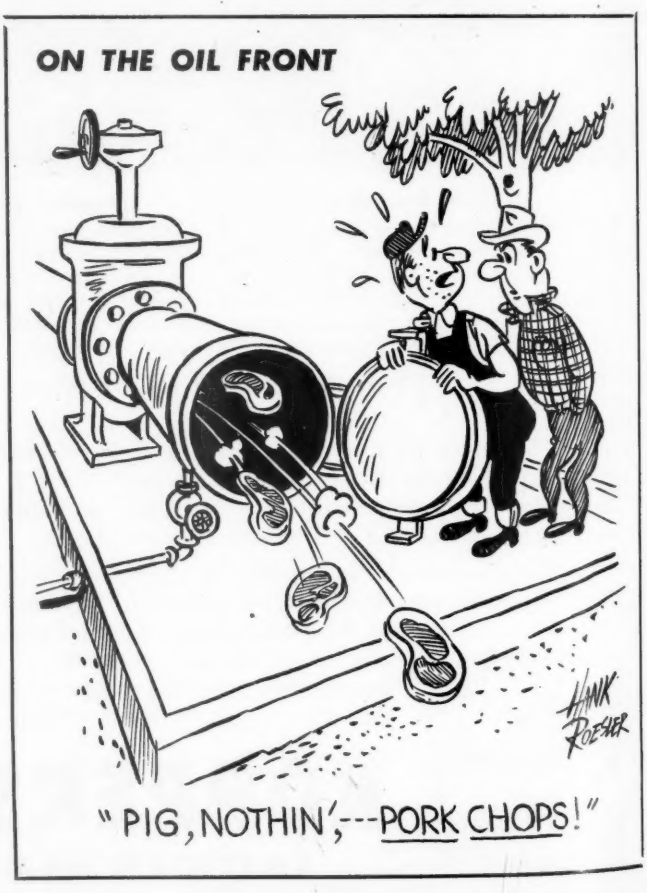
We sat at the dinner table with a very personable young guest from Calgary, Alberta, to wit, Joe Streeter, who is geologist and economic analyst in the petroleum and natural gas division of that very solid entity, the Canadian Bank of Commerce. Being ourself an erstwhile Calgarian we were soon reminiscing something dreadful and Joe was gentlemanly enough to listen while we recounted our adventures in the land of the Chinook.

But, returning to the Streeter saga, which after all is what we came for. Joe is a native of Edmonton with nice red cheeks to prove it. He took his B.Sc. at University of Alberta, and followed that with a masters in business administration from the University of Chicago. He was a member of Imperial Oil Company's geological staff and has conducted surveys in Northern Alberta and Saskatchewan, spending a considerable part of his time in the Leduc field.

More About Noted Canucks

He has also prospected for gold in Yellowknife and has, indeed, had a great deal more experience that you would expect such a well preserved young chap to have had. He seemed to be thoroughly impressed with the genuineness and generosity of the Nomad reception and was grateful no end for their interest. Joe, incidentally, once played college hockey which is difficult —he looks so marvelously whole. In a moment of madness many years ago in Winnipeg we snuck over to the corner lot and tried to horn into a hockey game with a flock of kids from a nearby kindergarten school. When we came to, most of the youngsters were away on their summer vacation.

Joe Streeter, by the way, was accompanied by another former Canuck, W. M. "Tom" Farrer, a legal whiz from the firm of Hill, Farrer, and Burrill. Tom was born in Norchester, New Brunswick, but has been so long in California that he speaks with a pronounced Beverly Hills accent. He is a sort of guardian without-portfolio of the L. A. Nomads, keeping them out of entangling alliances and thus saving them from being sued in open court on such ignominious charges as laches and estoppel, *e pluribus unum*, and *hasta la vista*.



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To obtain more information on products advertised see page E-49

Why Good Pipe Fitters Choose RIDGID 4P Geared Pipe Threader

No. 4P, 2½" to 4" pipe

Extra easy to carry and put on pipe

★ Balanced loop handles—easy to swing 4P where you want it.

★ Mistake-proof workholder sets to size *before* put on pipe—only one set screw.

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★ 4 sets of 5 high-speed steel dies for 2½", 3", 3½", 4" pipe. Ratchet handle; RIDGID Universal Drive Shaft available. Also special 4P for conduit.

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★★★ RIDGID Work-Saver Pipe Tools ★★★

Meetings

May 5-7—**American Geophysical Union,** National Academy of Sciences and National Research Council, Washington, D. C.

May 7-9—**Industrial Waste Conference,** Purdue University, Lafayette, Indiana.

May 8-9—**Fourth Oil Recovery Conference,** Texas Research Committee, Austin.

May 8-10—**Geological Society of America,** Rocky Mountain section, University of Utah, Salt Lake City.

May 9-10—**Interstate Oil Compact Commission,** spring meeting, Phoenix, Arizona.

May 11-14—**American Institute of Chemical Engineers,** National meeting, French Lick Springs Hotel, French Lick, Indiana.

May 12-13—**American Gas Association,** natural gas department spring meeting, Biltmore Hotel, Los Angeles, California.

May 12-13—**American Association of Petroleum Geologists,** regional meeting, Mayo Hotel, Tulsa, Oklahoma.

May 12-14—**Liquefied Petroleum Gas Association,** annual convention, Palmer House, Chicago, Illinois.

May 12-15—**American Petroleum Institute,** Refining Division midyear meeting, St. Francis Hotel, San Francisco, California.

May 13-16—**Intermountain Association of Petroleum Geologists,** third annual field conference, the basin and range province, from Cedar City, Utah, to Las Vegas, Nevada.

May 14—**Institute of Petroleum,** Manson House, 26, Portland Place, London W. I., England.

May 15-16—**American Gas Association,** executive conference, Ahwahnee Hotel, Yosemite Valley, California.

May 15-16—**American Petroleum Institute,** Division of Production, Pacific Coast, Biltmore Hotel, Los Angeles, California.

May 16—**American Petroleum Institute,** symposium on oil and gas, University of Kansas City, Missouri.

May 21-23—**Oil Industry Information Committee,** St. Francis Hotel, San Francisco.

May 22-23—**European Association of Exploration Geophysicists,** London, England.

May 26-28—**American Gas Association,** production and chemical conference, Hotel New Yorker, New York City, N. Y.

May 26-28—**American Petroleum Institute,** division of marketing, lubrication committee, Mayo Hotel, Tulsa, Oklahoma.

May 27-29—**Southwestern Gas Measurement Short Course,** University of Oklahoma, north campus, Norman, Oklahoma.

May 28-30—**Short Course in Gas Technology,** seventh annual, Texas College of Arts and Sciences, Kingsville, Texas.

May 29-30—**Society of Exploration Geophysicists,** Gulf Coast regional meeting, Rice Hotel, Houston, Texas.

June 1-6—**Society of Automotive Engineers,** Ambassador and Ritz-Carlton, Atlantic City, New Jersey.

DESK AND DERRICK CLUB

Dallas, Texas chapter, First Thursday of the Month.

Houston, Texas chapter, First Thursday of the Month.

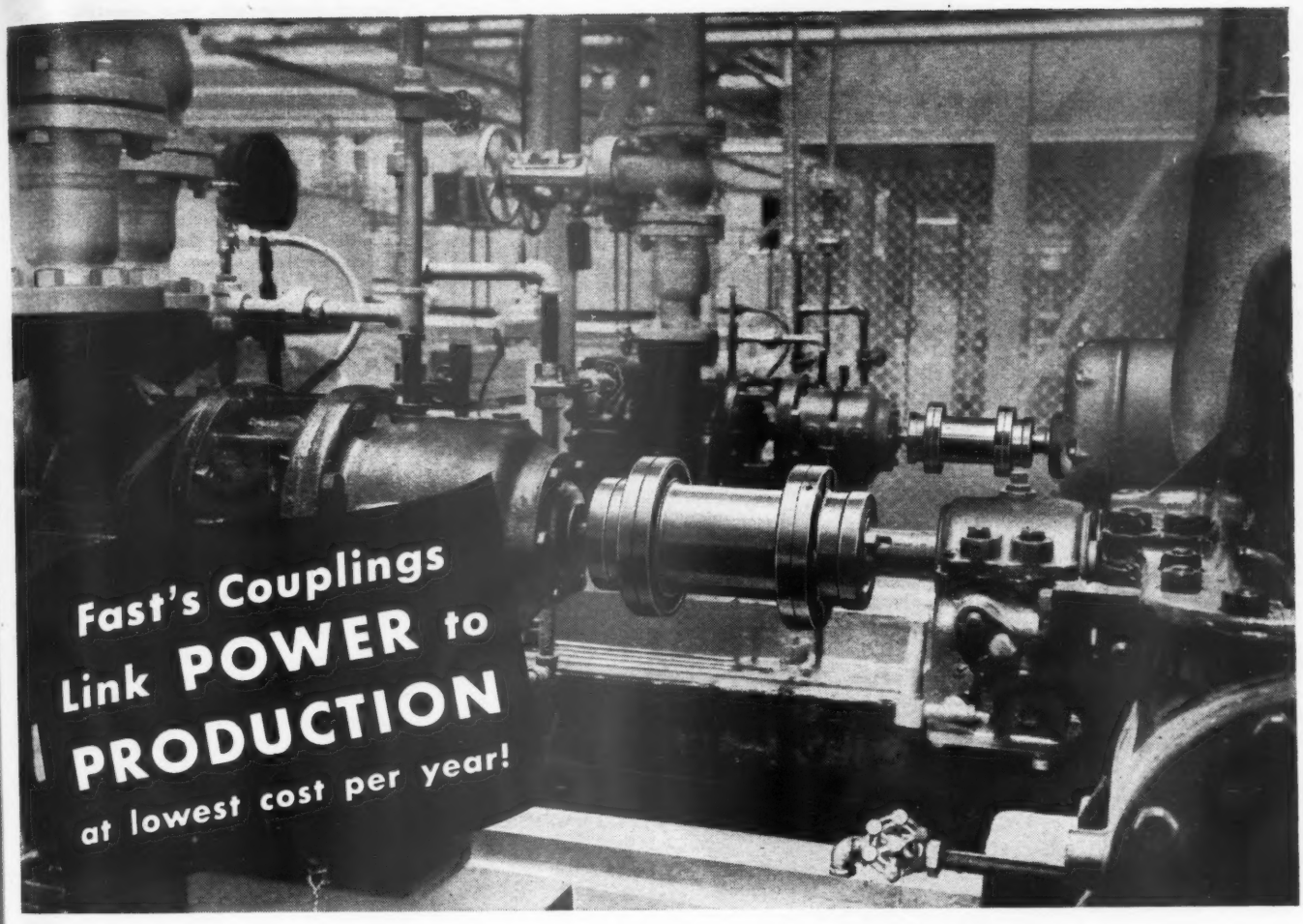
Jackson, Mississippi chapter, Third Tuesday of the Month.

Los Angeles, California chapter, Third day of the Month.

Odessa, Texas chapter, First Monday of the Month.

Shreveport, Louisiana chapter, Second Tuesday of the Month.

To obtain more information on products advertised see page E-49



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HIGH-SPEED equipment demands components with superior strength, accurate manufacture, long-lasting dependability. That's why it's important to *you* that Fast's Couplings are selected by every major high-speed equipment producer!

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Free Service—Koppers free engineering service assures you the right coupling for the job.

Rugged Construction—Fast's still maintains its original design, without basic change or sacrifice in size or materials. Result: freedom from expensive coupling failures.

Lowest Cost per Year—Fast's Couplings usually outlast equipment they connect. Their cost may be spread over many years!

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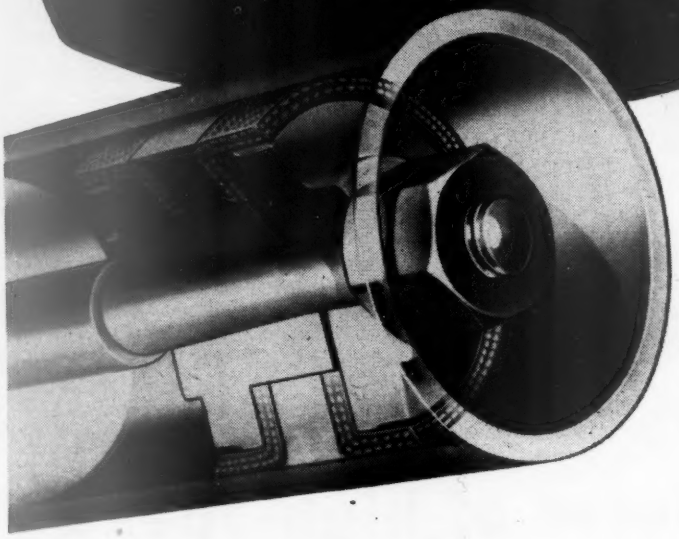

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June 5-6—**Pennsylvania Grade Crude Oil Association,** annual meeting, Hotel William Penn, Pittsburgh, Pennsylvania.

June 5-6—**National Society of Professional Engineers,** annual meeting, Tulsa, Oklahoma.

June 5-7—**National Oil Scouts and Landmen's Association,** annual convention, Hotel Hilton, Albuquerque, New Mexico.

June 8-12—**Canadian Gas Association**, Chateau Frontenac, Quebec City, Canada.

June 9-13—**Conference on Industrial Research,** Columbia University, New York City.

June 9-14—**American Petroleum Institute,** midyear standardization conference, Brown Plaza Hotel, Denver, Colorado.

June 12-13—**Western Petroleum Refiners Association,** regional technical and industrial-relations meeting, Broadview Hotel, Wichita, Kansas.

June 13-14—**Rocky Mountain Oil and Gas Association,** midyear directors' meeting, Great Falls, Montana.

June 16-22—**International Gas Conference,** Brussels, Belgium.

June 23-27—**American Society for Testing Materials,** annual meeting, Hotels Statler and New Yorker, New York City, New York.

July 1-Sept. 30—**Centennial of Engineering,** Museum of Science and Industry, Chicago.

Aug. 31-Sept. 2—**Interstate Oil Compact Commission,** summer meet, Banff, Canada.

Sept. 3-5—**Pacific Coast Gas Association,** Ambassador Hotel, Los Angeles, California.

Sept. 8-12—**National Instrument Conference and Exhibit,** Cleveland, Ohio.

Sept. 9-13—**National Chemical Exposition,** Chicago Coliseum, Illinois.

Sept. 10-12—**National Petroleum Association,** annual meeting, Hotel Traymore, Atlantic City, New Jersey.

Sept. 11-13—**American Institute of Chemical Engineers,** Palmer House, Chicago.

Oct. 1-3—**National Association of Corrosion Engineers,** south central region, Jung Hotel, New Orleans, Louisiana.

Oct. 4—**John Zink process heating seminar,** John Zink Company, Tulsa, Oklahoma.

Oct. 6—**Independent Natural Gas Association of America,** annual meeting, Fontenelle Hotel, Omaha, Nebraska.

Oct. 13-15—**Texas Mid-Continent Oil and Gas Association,** thirty-third annual meeting, Fort Worth, Texas.

Oct.19—**Natural Gasoline Association of America,** southern regional meeting, Blackstone Hotel, Tyler, Texas.

Oct. 20-21—**Independent Petroleum Association of America,** annual meeting, Tulsa.

Oct. 27-30—**American Gas Association,** annual convention, Atlantic City, New Jersey.

Nov. 10-13—**American Petroleum Institute,** annual meeting, Chicago, Illinois.

NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Louis Sherry's, New York. Secretary Jesse E. Hickman.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Secretary Jack Ballagh.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary M. W. Hiltpold.

DATA ON IMPORTANT OIL FIELDS OF THE UNITED STATES

No.	Year discovered	Field	County	Producing formation	Gravity °API	Productive acres	Estimated average thickness (feet)
				OKLAHOMA (Contd.)			
48	1935	Moore	Cleveland	Dolomite, U Simpson, 2nd Wilcox; Ord	41.0	940	—
49	1944	Moore, South	Cleveland	Wilcox; Ord	35.0	6,080	32
50	1943	Moore, West	Cleveland	Hunton, 2nd Wilcox, Sil; Dev, Ord	—	480	3
51	1928	Oklahoma City	Oklahoma	Simpson, Wilcox, Arbuckle	38.0	15,500	—
		Osage County					
52	1924	Atlantic	Osage	Burgess, Siliceous; Miss, Ord, Cam	39.0	1,330	20
53	1904	Avant	Osage	Bartlesville, Burgess; Pen	32.0	12,520	—
54	1943	Big Bend	Osage	Layton; Pen	41.0	160	16
55	1920	Burbank	Osage	Layton, Burbank, Wilcox; Pen Ord	38.0	24,665	60
56	1926	Burbank, South	Osage	Burbank, Skinner; Pen	38.0	4,465	—
57	1906	Flat Rock	Osage	Bartlesville, Burgess; Pen	34.0	7,485	50
58	1933	Naval Reserve	Osage	Burbank; Pen. Simpson (Homony); Ord	39.0	3,290	—
59	1904	Osage City	Osage	Burbank, Burgess, Arbuckle; Pen, Ord, Cam	37.0	3,805	—
60	1917	Osage Homony	Osage	Burgess, Layton, Oswego, Bartlesville; Pen	37.0	1,625	—
61	1912	Wildhorse	Osage	Various; Pen, Ord	35.0	4,670	—
		Seminole					
62	1935	Adams	Hughes	Misener	40.0	330	15
63	1927	Allen Deep	Seminole	Miss; Sil—Dev	36.0	3,400	—
64	1930	Asher, W	Pottawatomie	Wanetta	43.0	860	—
65	1936	Bethel, N	Seminole	Cromwell; Pen	40.0	300	20
66	1926	Bowlegs	Seminole	Hunton, Wilcox	40.0	4,050	30
67	1927	Carr City	Seminole	Hunton, Wilcox; Miss. Misener, Sil—Dev; Ord	40.0	1,885	—
68	1923	Cromwell	Okfuskee	Cromwell	37.0	5,425	—
69	1931	Dill	Okfuskee	Hunton, Sil-Dev	36.0	1,590	—
70	1935	Dora	Seminole	Boggy, Calvin; Pen	35.0	1,110	—
71	1926	Earlsboro	Pottawatomie	Earlsboro, Hunton, Wilcox, Simpson, etc	38.0	5,235	—
72	1929	Earlsboro, East	Seminole	Calvin, Hunton, Wilcox; Pen	39.0	2,105	—
73	1936	Earlsboro, North	Seminole	Hunton, Wilcox; Sil-Dev, Ord	41.0	460	—
74	1930	Earlsboro, South	Seminole	Wilcox, Calvin, Hunton; Pen	39.0	430	25
75	1934	Fish	Hughes	Pen, Ord	37.0	1,870	—
76	1932	Gray	Pottawatomie	Wanetta, Hunton, Simpson	40.0	320	25
77	1935	Grayson	Seminole	Simpson, Wilcox; Ord	40.0	530	20
78	1938	Hazel	Seminole	Thurman, Boggy; Pen	36.0	330	12
79	1933	Keokuk	Seminole	Misener, Hunton, Wilcox; Miss, Sil-Dev, Ord	40.0	2,200	—
80	1929	Konawa	Seminole	Earlsboro, Cromwell, Simpson; Pen, Ord	36.0	1,695	—
81	1927	Little River	Seminole	Hunton, Wilcox, Cromwell	38.0	4,090	—
82	1928	Little River, E	Seminole	Cromwell, Wilcox	36.0	910	—
83	1928	Maud	Pottawatomie	Misener, Hunton, Simpson	38.0	1,980	10
84	1928	Mission	Seminole	Hunton, Wilcox; Sil-Dev, Ord	39.0	1,570	—
85	1934	Olympic	Okfuskee	Senora, Cromwell; Pen	34.0	3,860	—
86	1923	Papoose	Hughes	Calvin, Gilcrease, Cromwell	36.0	2,815	10
87	1927	St. Louis	Pottawatomie	Dolomite, Simpson; Wilcox	38.0	19,905	—
88	1941	St. Louis, N	Pottawatomie	Hunton; Sil-Dev	37.0	1,000	16
89	1927	Sasakwa	Seminole	Wilcox, Cromwell	36.0	1,145	—
90	1926	Searight	Seminole	Hunton, Wilcox; Ord, Sil-Dev	38.0	2,110	—
91	1926	Seminole City	Seminole	Hunton, Wilcox	39.0	4,635	—
92	1926	Seminole, East	Seminole	Cromwell, Hunton, Wilcox	38.0	1,680	—
93	1935	Seminole, West	Seminole	Calvin, Wilcox; Pen, Ord	42.0	500	30
94	1934	Shawnee	Pottawatomie	Earlsboro; Pen	34.0	700	—
95	1942	Shawnee, N. E.	Pottawatomie	Wilcox; Ord	32.0	—	18
96	1923	Wewoka	Seminole	Cromwell, Hunton, Wilcox; Pen, Sil-Dev, Ord	37.0	2,015	—
97	1943	Wewoka Lake	Seminole	Booch	—	890	10
		Southeastern					
98	1913	Allen Shallow	Pontotoc	Allen	30.0	2,530	—
99	1923	Bebee	Pontotoc	Boggy, Hunton, Viola; Pen, Sil-Dev, Ord	36.0	2,530	—
100	1922	Brock	Carter	Arbuckle; Ord, Cam	32.0	765	—
101	1940	Cumberland	Marshall	Hunton, Bromide, McLish, Oil Creek	37.0	2,170	—
102	1933	Fitts	Pontotoc	Hunton, Viola, Bromide, McLish, Wilcox	39.0	5,955	—

From The Petroleum Data Book, Second Edition, which carries 750 pages of information on the petroleum industry.

DATA ON IMPORTANT OIL FIELDS OF THE UNITED STATES

No.	Annual production (thousands of barrels)						Cumulative production thru 1947 (M bbl)	Estimated recovery per acre (bbl)	Number wells producing		
	1942	1943	1944	1945	1946	1947			Total	Flowing	Pumping
							OKLAHOMA (Contd.)				
48	291	259	208	257	216	199	9,796	10,210	18	0	18
49	0	0	80	751	1,110	384	2,325	319	—	—	—
50	0	10	283	629	1,142	790	2,854	4,300	—	—	—
51	26,310	20,224	16,238	12,938	12,622	9,673	654,147	41,579	—	—	—
			Osage County								
52	305	296	291	270	267	245	5,955	4,293	90	0	90
53	781	774	789	748	710	660	98,370 Ⓔ	7,804	—	—	—
54	0	105	247	307	230	165	1,054	5,556	13	—	—
55	3,358	3,250	3,141	3,121	2,946	2,622	223,601	8,959	—	—	—
56	2,727	2,638	2,506	2,370	1,891	1,457	44,365	9,610	—	—	—
57	259	237	230	222	216	232	41,742 Ⓔ	5,546	562	0	562
58	948	832	725	604	502	444	20,977	6,376	—	—	—
59	285	228	201	184	161	155	53,915 Ⓔ	14,129	189	0	189
60	243	239	243	237	241	238	8,288	4,954	136	0	136
61	247	226	212	203	198	188	15,268 Ⓔ	3,229	380	0	380
			Seminole								
62	254	256	217	217	170	105	2,505	7,273	10	0	10
63	1,367	1,240	1,187	1,179	1,124	1,071	58,491	16,888	—	—	—
64	89	87	74	65	56	47	7,896	9,127	22	0	22
65	367	216	210	151	115	—	—	—	—	—	—
66	1,894	1,714	1,517	1,271	1,180	1,177	127,878	31,284	—	—	—
67	669	599	553	517	460	413	33,994	17,815	—	—	—
68	953	884	815	800	730	670	61,598	11,231	—	—	—
69	474	293	231	195	183	164	5,875	3,592	73	0	73
70	338	246	190	161	193	196	5,990	5,220	98	0	98
71	1,118	995	887	784	714	619	130,593	24,828	—	—	—
72	536	484	444	388	374	330	41,257	19,443	58	0	58
73	1,092	984	662	436	332	269	8,895	18,752	31	0	31
74	306	194	167	141	186	191	10,128	22,877	27	0	27
75	912	698	586	468	278	293	20,370	10,736	128	0	128
76	331	308	311	269	228	204	6,006	18,131	23	0	23
77	203	153	118	153	145	233	2,865	4,966	39	0	39
78	56	60	62	158	220	128	1,108	2,970	37	0	37
79	1,013	681	559	534	592	463	15,429	6,803	94	0	94
80	318	308	305	301	289	440	17,174	9,873	—	—	—
81	1,876	1,550	1,432	1,235	1,147	1,422	120,380	29,085	—	—	—
82	182	165	144	125	123	106	17,563	19,184	35	0	35
83	192	158	140	117	114	91	12,886	6,462	46	0	46
84	357	317	293	267	244	240	27,220	17,185	42	0	42
85	496	416	379	342	309	282	13,612	3,453	310	0	310
86	185	162	137	121	106	101	22,662	8,015	29	0	29
87	5,028	3,590	2,591	1,729	1,496	1,357	170,223	8,484	—	—	—
88	514	193	64	36	21	37	1,222	1,185	33	0	33
89	327	267	247	223	228	204	12,341	10,600	54	0	54
90	337	300	270	239	211	196	35,811	16,879	49	0	49
91	1,990	1,818	1,622	1,343	1,315	1,275	138,202	29,542	—	—	—
92	284	242	222	257	143	137	9,811	5,758	57	0	57
93	119	474	378	309	253	226	15,431	3,041	25	0	25
94	300	334	201	171	141	129	4,008	5,541	40	0	40
95	0	210	274	419	385	361	1,649	—	7	—	—
96	335	303	298	280	259	260	35,735	17,614	82	0	82
97	—	7	186	360	329	154	1,035	990	33	0	33
			Southwestern								
98	120	101	90	82	90	97	9,295	3,636	177	0	177
99	1,114	923	801	723	663	620	16,835	6,409	—	—	—
100	97	86	79	74	81	110	4,053	5,154	139	0	139
101	2,743	3,758	4,420	4,159	3,995	3,947	25,811	10,076	—	—	—
102	3,020	2,372	2,062	2,668	1,497	1,294	105,007	17,416	—	—	—

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LETTERS *to the* EDITORS

Gaging Technique

To The Petroleum Engineer:

I read and again reread Mr. H. L. Pohl's article in the March *Petroleum Engineer*. (Page D-28.)

I note he states the hydrometer should be left in the oil for "at least three minutes" before reading; also that the tank thermometer should "remain in the tank for at least five minutes".

I like Mr. Pohl's statement relative to a specified minimum time period during tests.

I have written a letter to Mr. W. T. Gunn, Secretary, Committee D-2 on Petroleum Products and Lubricants, American Society for Testing Materials, relative to establishing a specific time period for determining the gravity of crudes in conjunction with D 287.39.

In my letter to Mr. Gunn I made reference to occluded or absorbed air and that a period of time should be allotted for its escape before determining the gravity of the sample of oil under test.

A very clear illustration of the movements of the air that has been entrained and enclosed within a sample of crude during a gravity test may be had by filling a drinking glass with water heavily charged with air.

At first the water will present a milky appearance but almost instantly the two substances—i.e. air and water—will begin to arrange themselves according to their respective densities. The water being the more dense, hence the greater in weight, will slowly crowd the occluded air upward and out of its way until after a few minutes of time have elapsed the drinking glass will become a vessel of clear transparent water.

William T. Scheide.
1625 Shawnee Road
Lima, Ohio

Bouquet

To The Petroleum Engineer:

Your publication is looked for monthly and studied from cover to cover. The material is excellent. Keep up the good work. *T. G. Eastland.*

P. S. I read, "Laugh With Barney" first, so does the wife.

Assistant Manager,
M. O. Johnston Oilfield Service, Ltd.
Edmonton, Alberta, Canada

Copy to School

To The Petroleum Engineer:

As we are all pretty well swamped with work, and our nearest post office is 40 miles from here, I forgot to renew my subscription. We are getting quite a field around Lovington.

The copy of *The Petroleum Engineer* I get is used by a good many people, as I turn it over to the school here when I am through with it. The students in school now are the ones in the field tomorrow.

It would be nice if you could run a few articles on the different phases of the work in this area, although your magazine is good now. *R. E. Dendy.*

District Gager,
Texas-New Mexico Pipe Line Company,
Lovington, New Mexico

Soap Output to Double

More than one billion pounds of synthetic soap will be made from petroleum in the United States in 1951, according to forecasts at the Third World Petroleum Congress in Holland. Experts predicted that within another year or two, this output will be doubled. Detergents wash everything from silks to cars and from leather to vegetables.

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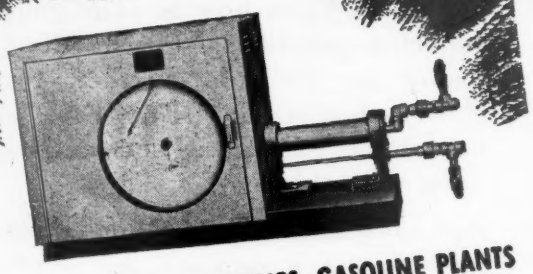

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P 910.

THE Petroleum Engineer

MAY
1952

Record Expenditures Bolster NATION'S OIL RESERVES

$ $ $ $ $ $ $ $ $ $ $ $ $

Exploration costs in 1951 are up three to one over crude oil price advance in the period since 1935

H. J. STRUTH*

At the greatest cost ever recorded, the petroleum industry in 1951 increased the nation's proved reserves of petroleum liquids by 2,688,000,000 bbl, after the year's record-breaking production of 2,450,000,000 bbl. Discoveries and upward revisions in previous estimates accounted for more than 5 billion barrels, the greatest quantity of oil ever credited to a single year, and lifted the nation's proved reserves to a new high level of more than 32 billion barrels.

Expenditures incurred in the search for new oil reserves in the United States last year topped those of any previous year with a total of nearly $1,740 million. This amount was equivalent to 35.4 per cent of the total working interest value of crude oil produced in 1951. It represented an increase in expenditures of more than $300,000,000, which comprised about one-half of the year's increase in the market value of crude oil credited to producers.

While crude oil prices have advanced 124 per cent from the extremely low levels of 1935-46, the facts indicate that petroleum exploration expenditures have, at the same time, shown an increase of 410 per cent. In other words, while the oil dollar has advanced to $2.24, the exploration expenditure dollar has been increased to $5.10. Relative to the price of crude oil, exploration costs are up 3.3 to 1 over the increase in oil prices. During the years 1935-46, when crude oil brought an average price of $1.14 per barrel, exploration expenditures averaged about $341,000,000 a year. In 1951, the average price of crude oil was $2.56, and the year's expenditures for exploration aggregated nearly $1,740 million.

The effect of price upon exploration activity and reserves discoveries is demonstrated by the gains that have accompanied the advance in crude oil prices. For every 100 exploratory wells drilled during the period 1935-46, the industry drilled last year 276 wells. Futhermore, for every 100 bbl of new reserves discovered in the earlier period, the industry discovered 233 bbl in 1951. Exploratory drilling, as measured by wildcat oil producers and all dry holes drilled in exploration and development, accounted for 18,760 wells in 1951. Initial oil discoveries credited to this activity aggregated 3,101 million barrels.

The initial cost of finding oil in 1951 averaged 65.6 cents per barrel, compared with an average cost in 1950 of 70.6 cents per barrel. Cost of drilling exploratory wells last year amounted to nearly $1,019 million dollars, or an average per well of $54,300. This was the cost of drilling alone. Expenditures for carrying leases, geological, geophysical, land department, overhead, and general office expenses aggregated $721,010,000, which added $38,300 per well drilled. The total cost of drilling exploratory wells in 1951 averaged $92,600 per well, compared with an average in 1950 of $88,600 per well. In the last three years, the average cost of drilling exploratory wells was $54,300, while the total cost, including other charges, averaged $90,430 per well. Compared with the period 1935-37, drilling costs have advanced to 4.4 times the former rate, while other charges are 1.8 times greater.

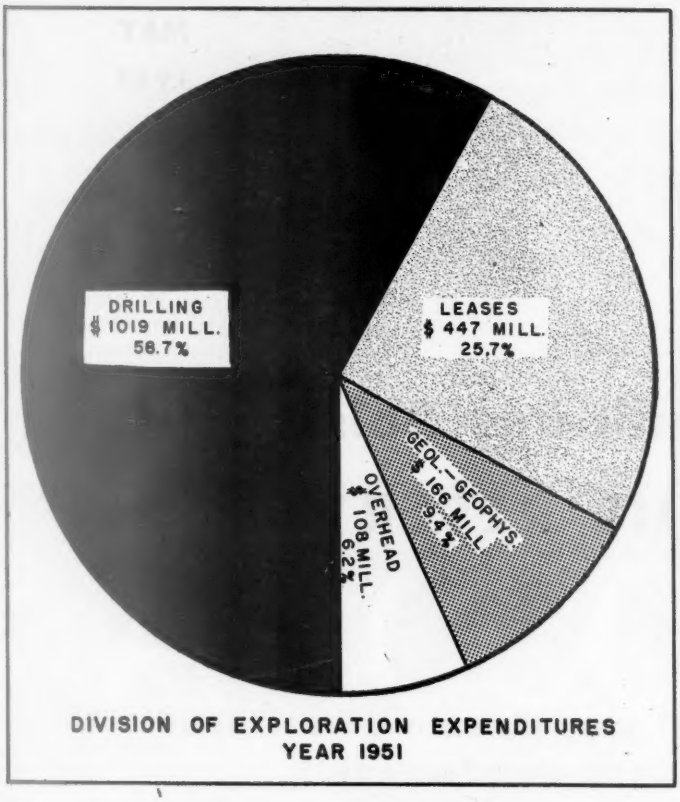
In the last 8 years, exploration expenditures have aggregated $8,549,152,000, which comprised 32.5 per cent of the total working interest value of the nation's oil production. The working interest value of all the crude oil produced during this period amounted to $26,274,469,000. Expenditures in 1951 of $1,739,575,000, compared with the net value of crude oil produced during the year, comprised 35.4 per cent. This is particularly significant in the light of attempts by high government officials to reduce or eliminate the 27½ per cent depletion allowance. The facts leave no doubt that the petroleum industry is actually spending far greater sums for replacement of its depleting assets than is contemplated by the statutory depletion allowance.

While greater effort accompanied the search for new oil fields in 1951, the results were below expectations. Oil found in new fields last year, by initial estimates, aggregated only 465,000,000 bbl, compared with 623,000,000 bbl in 1950 and 983,000,000 bbl in 1949. More discovery wells were drilled, but the size of the reserves found was smaller. The cost of exploring for new fields in 1951 aggregated about $706,000,000, which comprised an initial cost per barrel of

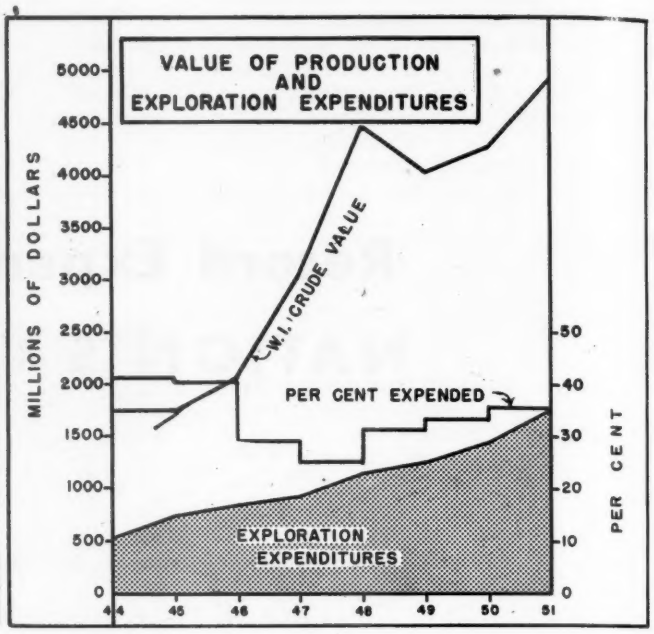
*Petroleum Economist.

EXCLUSIVE

This economic analysis of drilling and producing results and costs by H. J. Struth, a leading consultant on petroleum economics, is an annual feature of The Petroleum Engineer.



DIVISION OF EXPLORATION EXPENDITURES
YEAR 1951



working interest oil found of $1.77. In the last 5 years, the average cost of finding oil reserves in new fields was about $1.18 per barrel. In 1951, the average cost of finding oil by extension drilling was about 46 cents per barrel, while the average cost of all reserves found by exploration drilling was 65.6 cents per barrel. About 83 per cent of the wells drilled in attempts to find new oil fields were dry holes. Only 1 out of 6 wells drilled were productive. At a cost of $90,000 per well, including drilling and other charges, this means an expenditure of some $540,000 to find one producer signifying a new oil field.

The state of Texas continued to report spectacular gains in petroleum liquids reserves in 1951. The state reported combined discoveries and revisions of 3,251 million barrels, which accounted for 63 per cent of all the reserves found in 1951. Reserves at the close of 1951 aggregated 18,192 million barrels, which comprised 56 per cent of the national total. California, Louisiana, Oklahoma, and Wyoming followed, in the order named, with reserves ranging downward from 4,090 million barrels to 1,019 million barrels. These states led also in the quantity of new reserves discovered. Ten states reported a combined decline in proved reserves of 711,000,000 bbl. In these states discoveries failed to offset the year's productive requirements. Over 90 per cent of the reserves found in 1951 were credited to Texas, Louisiana, California, Illinois, Kansas, New Mexico, Oklahoma, Wyoming, and Mississippi.

In response to the growing demand for oil, and the need for an adequate margin of productive capacity, oil operators drilled last year the greatest number of exploratory wells ever reported. The new high record of 18,760 wells was 2.5 times the number drilled in 1944. The success attending this effort, as measured by the quantity of reserves added to the underground inventory, was perhaps the most gratifying in the oil industry's history. The results attained in 1951 went far to prove that the nation is not in any near-term danger of "running out of oil." Incentive to explore for and to find oil is paramount to the future outlook for the nation's petroleum reserves and availability of an adequate oil supply. With the cost of finding oil ascending to heights that are beyond the reach of "shoestring" operators, it is obvious that the price of crude oil and the retention of present statutory depletion allowance are the primary considerations attendant upon the continued, intensive pursuit of oil exploration in the United States.

Studies of initial and ultimate re-

TABLE 1. Petroleum exploration expenditures, year 1951, preliminary estimates.

	Total cost	Cost per bbl
Drilling cost	$1,018,565,000	$.384
Cost of carrying leases, (rentals and bonuses)	447,020,000	.169
Geological and geophysical cost, including land dept.	165,830,000	.063
Overhead and general office	108,160,000	.040
Total	$1,739,575,000	$.656
Exploratory wells drilled[1]	18,760	
Drilling cost per well[2]	$54,300	
Total cost per well	$92,600	
New oil reserves discovered		
New fields and new pays	464,750,000	
Extensions	2,636,588,000	
Total[3]	3,101,338,000	
Working interest (85.5%)	2,651,644,000	
Initial finding cost per bbl	$.656	

[1] Includes wildcat oil producers and all dry holes.
[2] Includes cost of equipping producing wells.
[3] Excludes revisions in previous estimates of 2,037 million barrels.

TABLE 2. Cost of exploration and value of oil production.

Year	Gross crude production (thous. bbl)	Working interest (85.5%) (thous. bbl)	Price per bbl	Value of working interest prod. (thous. $)	Exploration expenditures (thous. $)	Per cent of W. I. value
1944	1,677,904	1,434,608	$1.20	$ 1,721,530	$ 517,659	30.1
1945	1,713,655	1,465,175	1.20	1,758,210	731,207	41.6
1946	1,733,939	1,482,518	1.39	2,060,700	826,186	40.1
1947	1,856,987	1,587,724	1.92	3,048,430	904,332	29.7
1948	2,020,185	1,727,258	2.59	4,473,598	1,135,476	25.4
1949	1,841,940	1,574,859	2.55	4,015,890	1,255,367	31.2
1950	1,971,845	1,685,927	2.54	4,282,255	1,439,350	33.6
1951(p)	2,245,000	1,919,475	2.56	4,913,856	1,739,575	35.4
Total 8 yrs.	15,061,455	12,877,544	$2.04	$26,274,469	$8,549,152	32.5

(p) Preliminary estimates.

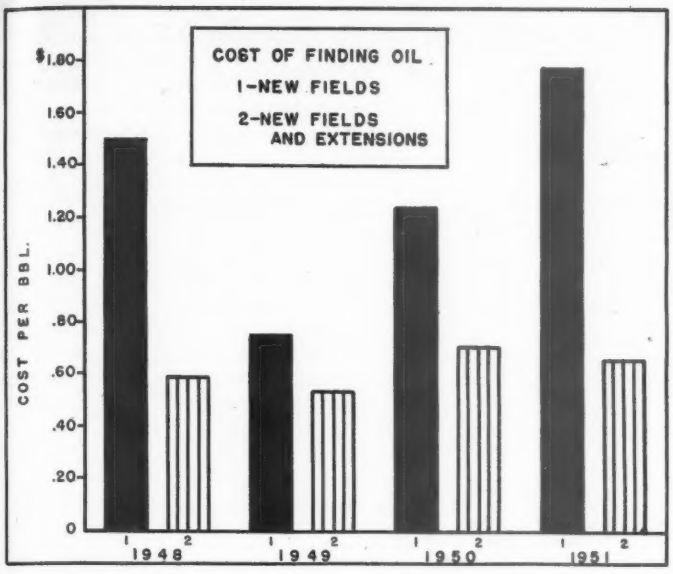


TABLE 3. Initial cost of finding oil in new fields. (Extension drilling excluded).

	1947	1948	1949	1950	1951 (p)	Total 5 years
New reserves discovered (Mill. Bbl)	505	461	983	623	465	3,037
Working interest (85.5%) (Mill. Bbl)	432	394	840	533	398	2,597
Discovery wells drilled	660	783	880	980	1,320	4,623
Dry holes drilled	3,750	4,437	4,635	4,855	6,470	24,147
Total wells drilled	4,410	5,220	5,515	5,835	7,790	28,770
Drilling cost (Thous. $)	374,860	443,700	479,805	504,700	539,350	2,342,415
Other cost[1] (Thous. $)	114,034	143,881	150,860	156,500	166,660	731,935
Total cost (Thous. $)	488,894	587,581	630,665	661,200	706,010	3,074,350
Cost per bbl	$1.13	$1.49	$0.75	$1.24	$1.77	$1.18

[1] Includes leases, geological, geophysical and overhead cost.
p Preliminary estimates.

serves discoveries indicate that it takes at least eight years to develop an oil prospect. Thus, while it takes an average of 12 drill-tests to locate one producer in a prospective oil field, it may be necessary to drill 144 wells, of which 120 will be dry holes, to develop a typical oil field to determine the ultimate reserves in place. Experience has shown that development of an oil field, subsequent to drilling the initial discovery well, extends over a period of from five to eight years, depending upon the area involved. Discovery data for the year 1951 show that only 465,000,000 bbl were discovered in new fields and new pays. Over 90 per cent of the reserves credited to 1951 comprised oil developed by extension drilling, and by upward revisions in previous estimates.

Back-credits to original discoveries, from reserves credited to extension drilling and revisions, have played a highly important part in the maintenance of an adequate petroleum supply in the United States. Many newly-discovered oil fields are shown to contain relatively small reserves by initial estimates, only to be proved by subsequent development to contain far greater recoverable reserves. Yet, it is only by continued effort, at great expense, that each year's new prospects are developed to determine their ultimate recoverable reserves in place. Initial oil finding costs are subsequently reduced by upward revisions in estimates of original new-field discoveries. Over the last 8 years, for example, the average initial finding cost was about 57 cents per barrel, but credits for revisions had the effect of reducing initial costs to an average of about 40 cents per barrel. This does not, of course, include the cost of development of an oil pool, nor does it include the cost of production. The facts prove that replacement costs, on a revised cost basis, have increased more than fivefold since the pre-war period 1935-37, from an average of 9 cents to 47.4 cents per barrel. During this period initial oil finding costs have increased from 13 cents per barrel to 62.6 cents per barrel. These calculations are based upon three-year moving averages.

Despite the fact that the quantity of new reserves discovered in 1951 was the greatest in the oil industry's history, the incidence of discovery per well was lower than in any previous year. Measured by the sum of exploration expenditures, the industry found an average of 1.8 bbl of new reserves per dollar spent in such effort. In the pre-war period, 1935-37, reserves discoveries averaged 8.7 bbl for each exploratory dollar expended. This emphasizes the growing need for drilling a greater number of wells each year, and the necessity for constantly greater expenditures in exploratory effort. The facts prove that the capital risks attending the search for new sources of oil supply are today five times greater than they were in the pre-war period 1935-37. Expenditures for exploration are 9 times greater, while the results are only 20 per cent of those recorded in the earlier years.

Profits reported by oil companies today are not as large as they may seem, in the light of current and future replacement costs. High returns reported by many companies are the result of producing oil which was discovered 10 or 15 years ago, when costs were far below what they are today. Financial trends in the oil industry indicate that substantially greater proportions of returns are being reinvested in new properties, plants, and equipment. In recent years, capital investments have exceeded net profits by a substantial margin, with the result that the use of borrowed capital is being employed to a greater extent than in the pre-war years. Profits of oil producing companies are minimized by the fact that reserves replace-

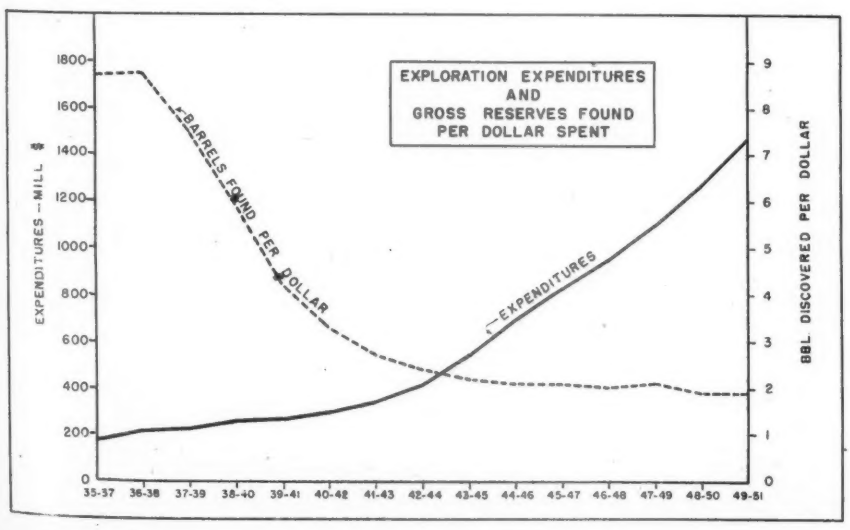
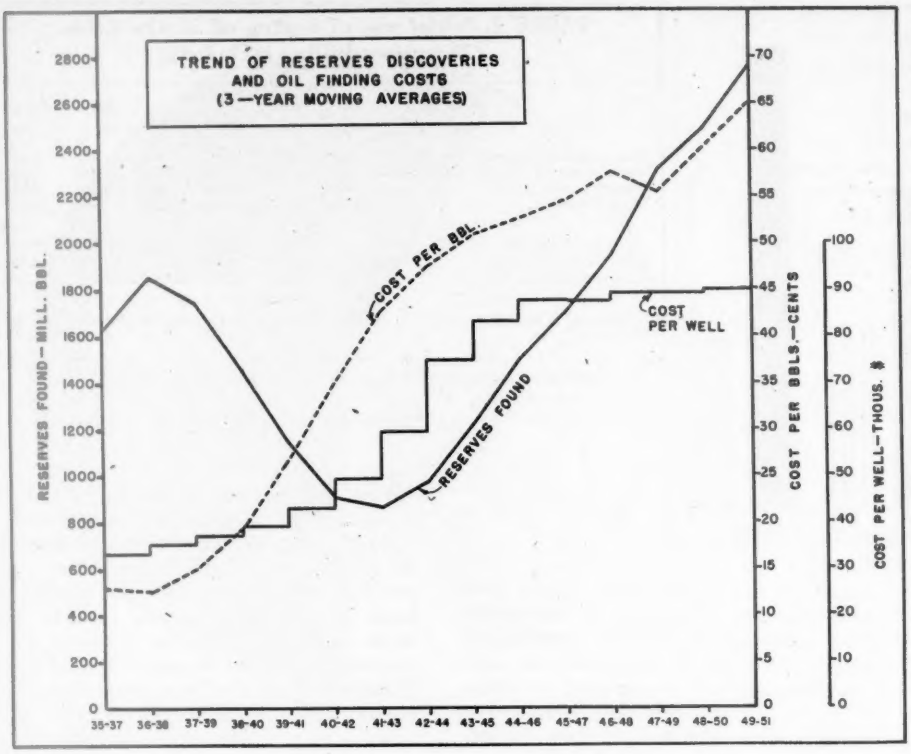


TABLE 4. Trend of reserves discoveries and expenditures. (3-year moving averages)

Period	Annual expenditures (thous. $)	Annual reserves discovered[1] (mill. bbl)	Reserves discovered per dollar spent[2] (bbl)
1935-37	187,648	1637	8.7
1936-38	207,901	1848	8.9
1937-39	231,631	1744	7.5
1938-40	245,990	1441	5.9
1939-41	272,516	1150	4.2
1940-42	284,870	919	3.3
1941-43	330,340	876	2.7
1942-44	402,973	964	2.4
1943-45	552,847	1231	2.2
1944-46	691,484	1486	2.1
1945-47	820,575	1702	2.1
1946-48	955,330	1932	2.0
1947-49	1,098,391	2320	2.1
1948-50	1,276,730	2483	1.9
1949-51p	1,478,096	2760	1.9
Year 1951p	1,739,575	3101	1.8

[1] Initial reserves found in new fields and extensions.
[2] Gross barrels, including royalty oil.
p Preliminary estimates.


TREND OF RESERVES DISCOVERIES
AND OIL FINDING COSTS
(3—YEAR MOVING AVERAGES)
RESERVES FOUND—MILL. BBL.
COST PER BBL.
COST PER WELL
RESERVES FOUND
COST PER BBLS.—CENTS
COST PER WELL—THOUS. $
35-37 36-38 37-39 38-40 39-41 40-42 41-43 42-44 43-45 44-46 45-47 46-48 47-49 48-50 49-51

ment costs are five times greater than in the pre-war years, and by the fact that expenditures for exploration are now nine times greater. Replacement of productive facilities, as well as oil underground, is now in multiples of original costs and must of necessity be compensated for by continued large returns from capital investments. The situation with respect to the petroleum industry involves a great deal more than just the devaluation of the dollar.

In the light of constantly rising costs, many oil operators oppose government control of crude oil prices. Prices of crude oil have remained almost stationary since 1948, when the average price was $2.59 per barrel, against $2.56 today. Meanwhile the industry's costs have increased, without additional compensation. The history of the oil industry reveals a constant relationship between exploratory drilling and the price of crude oil. When oil prices are depressed to a low level, exploratory drilling activity drops in direct ratio to the decline in oil prices. While oil prices have advanced from the low levels of the war years, they have lagged far behind the rise in all other commodity prices. While existing prices have influenced the high level of exploratory drilling activity, there is reason to believe that this trend has in no small part been under the influence of expectancy of a long-needed increase in crude oil prices.

Many oil operators have pinned their faith upon the Capehart formula, believing that some upward adjustment in prices would be granted. If the need for higher crude prices is recognized by government price fixers, it will no doubt redound in further acceleration of exploratory drilling activity in the United States.

The ability of the oil industry to meet near-future oil requirements of the nation is indicated by the steady growth in the number of producing oil wells, and also in the quantity of reserves available per well. Since 1935, the number of oil wells has increased from 340,990 to 474,000. At the same time the quantity of proved reserves per well has increased from 42,500 bbl to 68,130 bbl at the close of 1951. Preliminary drilling statistics indicate that the industry completed last year a total of 23,065 oil wells. Well abandonments last year aggregated about 10,865, which was equivalent to 47 per cent of the new oil wells brought into production. In the last five years, the industry completed 108,971 new oil wells and abandoned 64,431

TABLE 6. Producing oil wells and reserves per well.

Year	Number of producing wells (Dec. 31)	Proved reserves (mill. bbl) *	Reserves per well (bbl)
1935	340,990	14,492	42,500
1936	349,450	15,160	43,380
1937	363,030	17,622	48,540
1938	369,640	19,507	52,770
1939	380,390	20,690	54,390
1940	389,010	21,281	54,700
1941	399,960	21,873	54,690
1942	404,840	22,383	55,290
1943	407,170	22,399	55,010
1944	412,220	22,710	55,090
1945	415,750	23,184	55,764
1946	421,460	24,027	57,008
1947	429,637	24,755	57,681
1948	437,880	26,854	61,327
1949	448,680	28,430	63,809
1950	461,800	29,605	64,150
1951p	474,000	32,293	68,130

* Includes natural gas liquids, partly estimated.
p Preliminary estimates.

TABLE 5. Cost of exploration and oil finding in the United States.

	Initial reserves found (mill. bbl) (a)	Working interest (85.5%) (mill. bbl)	Revised reserves found (mill. bbl) (b)	Working interest (85.5%) (mill. bbl)	Exploratory wells drilled (c)	Drilling cost (thous. $)	Other costs (thous. $) (d)	Total cost (thous. $)	Initial cost per bbl	Revised cost per bbl	Cost per well: Drilling	Cost per well: Total
1944	1,243	1,063	2,266	1,937	7,503	240,479	277,180	517,659	$ .487	$ .267	$32,051	$68,994
1945	1,581	1,352	2,705	2,313	8,187	365,557	365,650	731,207	.541	.316	44,650	89,313
1946	1,635	1,398	2,616	2,237	9,403	420,386	405,800	826,186	.591	.369	44,708	87,864
1947	1,892	1,618	3,043	2,602	10,401	481,982	422,350	904,332	.559	.347	46,340	86,947
1948	2,270	1,941	2,952	2,524	12,850	602,575	523,901	1,135,476	.585	.450	46,890	88,364
1949	2,798	2,392	3,445	2,945	14,025	696,622	558,745	1,255,367	.525	.426	49,670	89,505
1950	2,382	2,037	3,044	2,603	16,249	821,750	617,600	1,439,350	.706	.552	50,570	88,600
1951 (p)	3,101	2,651	....	....	18,760	1,018,565	721,010	1,739,575	.656	....	54,300	92,600
Three-year moving averages												
1935-37	1,637	1,449	2,431	2,078	5,760	67,318	120,330	187,648	.130	.090	11,687	32,578
1936-38	1,848	1,635	2,662	2,276	6,161	75,277	132,624	207,901	.127	.091	12,218	32,745
1937-39	1,744	1,543	2,480	2,120	6,525	83,779	146,834	231,613	.150	.109	12,840	35,496
1938-40	1,441	1,275	2,311	1,976	6,607	88,836	157,154	245,990	.193	.124	13,446	37,232
1939-41	1,150	1,018	2,040	1,744	6,969	101,696	170,820	272,516	.268	.156	14,593	39,104
1940-42	919	813	1,844	1,578	6,750	111,351	173,519	284,870	.350	.181	16,496	42,303
1941-43	876	775	1,701	1,454	6,679	133,644	196,696	330,340	.426	.227	20,010	49,459
1942-44	964	853	1,940	1,659	6,717	174,083	228,890	402,973	.472	.243	25,917	59,993
1943-45	1,231	1,089	2,291	1,959	7,464	257,027	295,820	552,847	.508	.282	34,435	74,068
1944-46	1,486	1,315	2,529	2,162	8,364	342,141	349,543	691,484	.526	.319	40,906	82,698
1945-47	1,702	1,506	2,788	2,384	9,330	422,642	397,933	820,575	.545	.344	45,299	87,950
1946-48	1,932	1,652	2,870	2,474	10,884	501,647	453,683	955,330	.578	.386	46,086	87,765
1947-49	2,320	1,984	3,146	2,690	12,428	593,726	504,665	1,098,391	.553	.409	47,785	88,402
1948-50	2,483	2,123	3,147	2,691	14,374	706,982	569,748	1,276,730	.601	.474	49,043	88,823
1949-51p	2,760	2,360	....	....	16,345	845,865	632,451	1,478,096	.626	....	51,737	90,430

(a) Oil found in new fields and extensions to previous discoveries.
(b) Revisions in previous estimates allocated to original discovery years.
(c) Wildcat oil producers and all dry holes drilled.
(d) Includes leases, geological, geophysical and overhead costs.
(e) Effect of revisions in previous estimates, allocated to discovery years.
(p) Preliminary estimates.

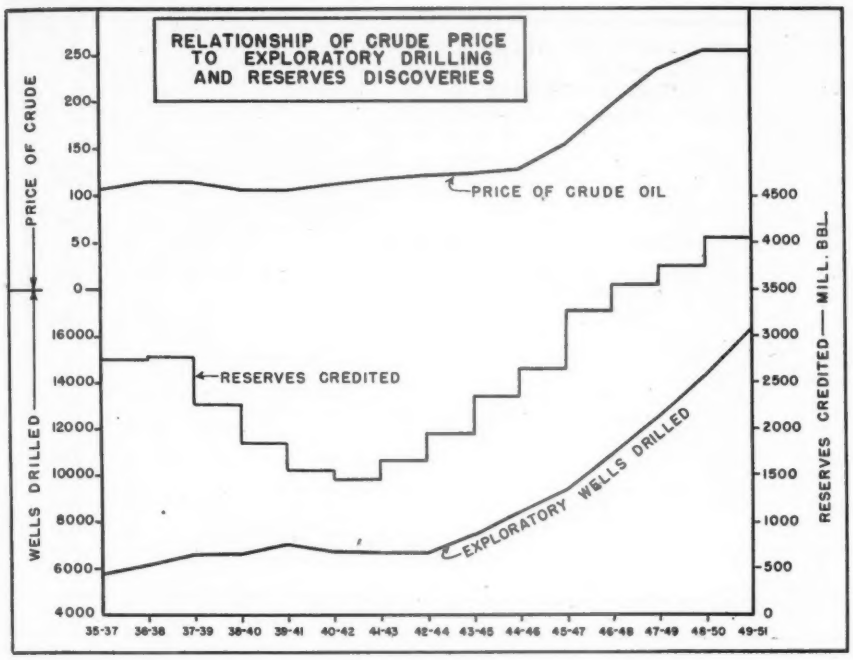

RELATIONSHIP OF CRUDE PRICE TO EXPLORATORY DRILLING AND RESERVES DISCOVERIES
PRICE OF CRUDE
WELLS DRILLED
RESERVES CREDITED — MILL. BBL.
PRICE OF CRUDE OIL
RESERVES CREDITED
EXPLORATORY WELLS DRILLED
35-37 36-38 37-39 38-40 39-41 40-42 41-43 42-44 43-45 44-46 45-47 46-48 47-49 48-50 49-51

TABLE 7. Exploratory wells drilled, reserves dicovered and price of crude oil. (3-year moving averages)

Period	Exploratory wells drilled (1)	Reserves credited (mill. bbl) (2)	Price of crude oil per bbl
1935-37	5,760	2220	$1.08
1936-38	6,161	2781	1.13
1937-39	6,525	2794	1.11
1938-40	6,607	2248	1.05
1939-41	6,969	1807	1.06
1940-42	6,750	1509	1.11
1941-43	6,679	1442	1.17
1942-44	6,717	1629	1.20
1943-45	7,464	1929	1.21
1944-46	8,364	2425	1.28
1945-47	9,330	2634	1.52
1946-48	10,884	3286	1.97
1947-49	12,428	3518	2.35
1948-50	14,374	3723	2.56
1949-51p	16,345	4014	2.55

(1) Wildcat oil producers and all dry holes drilled.
(2) Includes oil found in new fields, extensions and revisions in previous estimates.
(p) Preliminary estimates.

wells. Roughly, 60 per cent as many wells completed during this period were abandoned. This turnover illustrates the fact that there can be no let-up in drilling if the nation is to be adequately supplied with oil, without interruption.

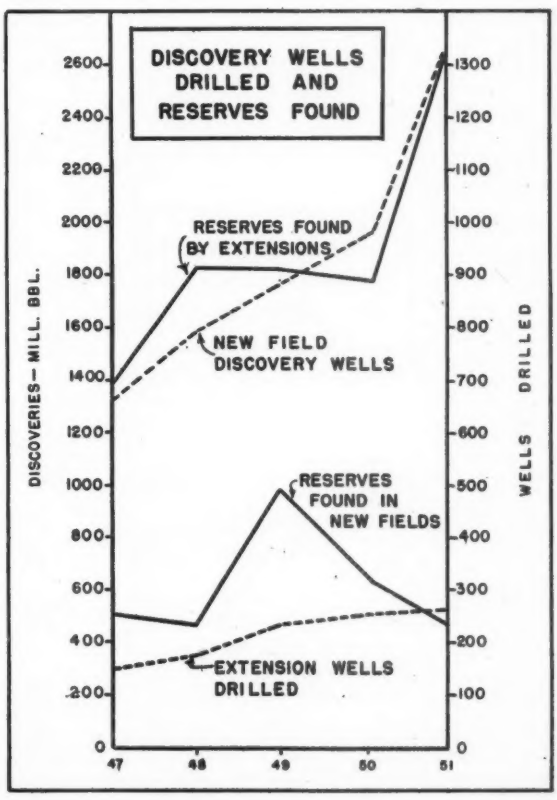
The search for new oil fields was less productive in 1951 than in 1949 and 1950. While the number of discovery wells drilled increased from 980 in 1950 to 1320 in 1951, the quantity of reserves initially discovered dropped from 636,000 bbl per well in 1950 to only 465,000 bbl per well in 1951. In 1949, 880 discovery wells found reserves which averaged 1,117,000 bbl per well. In the last 5 years, the quantity of reserves found in new fields, averaged about 657,000 bbl per well. Extension drilling was far more productive in 1951, when the completion of 260 extension wells yielded an average of 10,142,000 bbl per well. In 1950, 245 such wells found an average of 7,180,000 bbl per well. In the last 5 years, the quantity of reserves found by extension drilling averaged 8,900,000 bbl per well. An index of the results of exploratory drilling is found by dividing the total number of wildcat producers and all dry holes into the initial reserves discovered in new fields and extensions. This indicates an average discovery rate of 165,000 bbl per well in 1951, and an average for the last five years of 172,000 bbl per well.

Extension of these studies to embrace all types of wells drilled reveal varying results and indices which serve as guides to possible future drilling results. In the last seven years, total reserves discoveries measured by all wildcat drilling indicated an average per well of 460,000 bbl. This is a marked decrease in yield from the level established during the period 1935-37, when the rate per wildcat was 1,407,000 bbl. If we use dry holes as an index, we find that the average quantity of reserves found per dry hole drilled during the last seven years was 252,000 bbl, compared with an average per well during 1935-37 of 493,000 bbl per dry hole. Reserves discoveries, as measured by all wells drilled in ex-

TABLE 8. Drilling and exploratory results.

	1947	1948	1949	1950	1951p	Total 5 years
Wildcats:						
Oil wells (new fields)	660	783	880	980	1,320	4,623
Oil wells (extensions)	142	177	233	245	260	1,057
Gas wells	207	245	203	233	260	1,148
Dry holes	4,192	5,100	5,556	6,606	8,375	29,829
Total	5,201	6,305	6,872	8,064	10,215	36,657
Development dry holes	5,407	6,790	7,356	8,418	8,805	36,776
Total exploratory wells	10,608	13,095	14,228	16,482	19,020	73,433
Development oil wells	17,235	21,068	20,697	22,806	21,485	103,291
Development gas wells	3,183	2,584	2,776	2,684	2,710	13,937
Total drilled for oil and gas	31,026	36,747	37,701	41,972	43,215	190,661
Service wells	2,264	2,159	1,184	1,215	1,230	8,052
Total all wells drilled	33,290	38,906	38,885	43,187	44,445	198,713
New Fields—New Pays						
Oil wells completed	660	783	880	980	1,320	4,623
Reserves found (mill. bbl)	505	461	983	623	465	3,037
Average per well (thous. bbl)	765	588	1,117	636	352	657
Extensions						
Oil wells completed	142	177	233	245	260	1,057
Reserves found (mill. bbl)	1,387	1,809	1,815	1,759	2,637	9,407
Average per well (thous. bbl)	9,768	10,229	7,790	7,180	10,142	8,900
Composite						
Oil wells completed	802	960	1,113	1,225	1,580	5,680
Reserves found (mill. bbl)	1,892	2,270	2,798	2,382	3,102	12,444
Average per well (thous. bbl)	2,359	2,364	2,514	1,944	1,962	2,190
Total Exploratory Wells						
Completions*	10,401	12,850	14,025	16,249	18,760	72,285
Reserves found (mill. bbl)	1,892	2,270	2,798	2,382	3,102	12,444
Average per well (thous. bbl)	182	176	200	147	165	172

* Excluding gas wells. p Preliminary estimates.


DISCOVERY WELLS DRILLED AND RESERVES FOUND
RESERVES FOUND BY EXTENSIONS
NEW FIELD DISCOVERY WELLS
RESERVES FOUND IN NEW FIELDS
EXTENSION WELLS DRILLED
DISCOVERIES — MILL. BBL.
WELLS DRILLED
47 48 49 50 51

ploration and development, excluding service wells, reveals an average per well during the last seven years of 82,000 bbl. This compares with an average per well during 1935-37 of 105,000 bbl.

The need for increased drilling activity is indicated by the record of wells drilled per million barrels of reserves discovered. In 1951, it was necessary to drill 6 exploratory wells to find 1,000,000 barrels of reserves. During the prewar period 1935-37, the industry had to drill only 3.5 exploratory wells to find 1,000,000 bbl of new oil reserves. In the last seven years, the average was 5.7 wells per million barrels of reserves found. It was necessary in 1951 to drill 3.3 wildcat wells per million barrels of reserves found, which compares with an average of 1.2 wildcats per million barrels in 1935-37. The index of all wells drilled is more consistent. In 1951, the industry drilled an average of 13.9 wells per million barrels of reserves discovered, compared with an average during 1935-37 of 15.9. The average during the last seven years has been 15.5 wells drilled per million barrels of reserves discovered. If the industry drills 50,000 wells in 1952, it is likely that the aggregate, initial reserves discoveries will amount to at least 3,550 million barrels. To this would be added the increment represented by upward revisions in previous estimates. This figure exceeded 2 billion barrels in 1951.

In the last four years, the annual reserves credits, combining reserves discoveries and revisions in previous estimates, have averaged 1.86 bbl for each barrel of oil produced. Discoveries during this period aggregated 16,308 million barrels, while production amounted to 8,770 million barrels. If this rate is maintained this year, and if the production of petroleum liquids attains a total of 2,575 million barrels, it will be necessary for the industry to find about 4.9 billion barrels of reserves, including new discoveries and revisions in previous estimates. Reserves credited to 1951, of 5,138 million barrels represented nearly 2.1 bbl for each barrel of production. A long-range view seems to indicate the necessity of a 2 to 1 ratio of discoveries to production, in order to meet growing market requirements and to maintain an adequate margin of availability in excess of current needs.

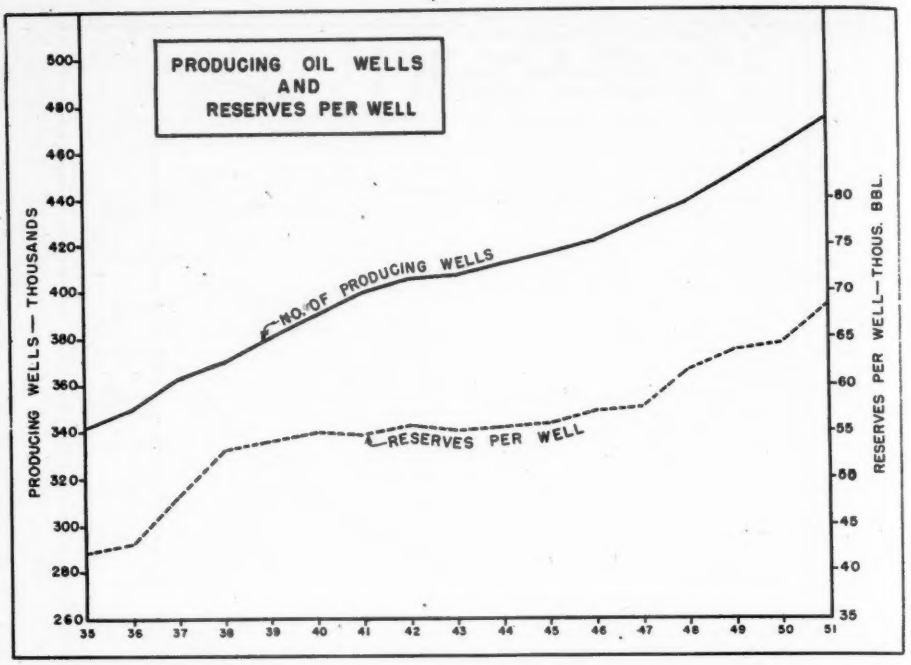


TABLE 9. Reserves discoveries related to drilling activity. (Revised to include 1951 revisions in previous estimates.)

Average	New reserves found[1] (mill.bbl)	All wildcats drilled: Number wells	All wildcats drilled: Reserves found per well (thous.)	All wildcats drilled: Number wells	All wildcats drilled: Reserves found per well (thous.)	Dry holes drilled: Number wells	Dry holes drilled: Reserves found per well (thous.)
1935—37	2,744	1,949	1,407	25,994	105	5,542	493
1945	2,705	4,105	658	24,833	109	7,646	353
1946	2,616	4,615	566	27,412	95	8,764	298
1947	3,043	5,201	585	31,026	98	9,599	317
1948	2,952	6,305	468	36,747	80	11,890	248
1949	3,445	6,872	501	37,701	91	12,912	266
1950	3,044	8,064	377	41,972	72	15,024	202
1951p	3,101[2]	10,215	303	43,215	71	17,180	180
Total 7 years	20,906	45,377	460	242,906	82	83,015	252

[1] Reserves discovered in new fields and extensions, plus allocated credits for revisions in previous estimates.
[2] Initial discoveries only, subject to subsequent revisions. p Preliminary estimates.

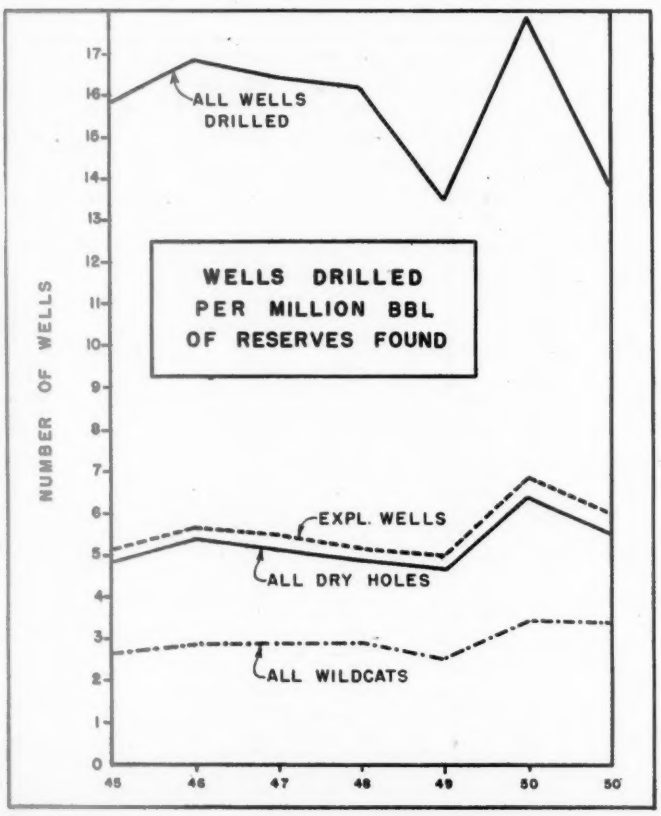
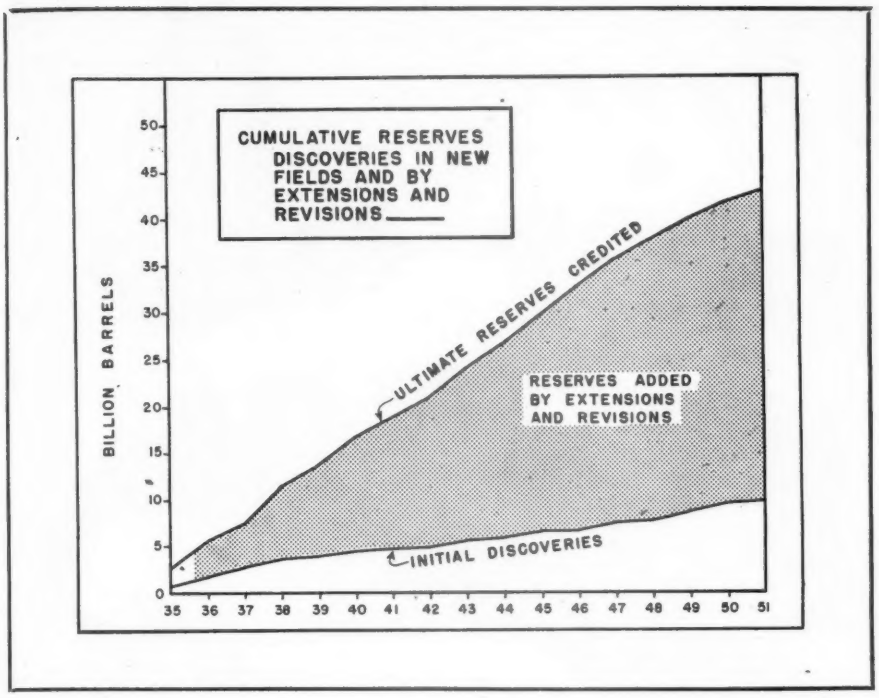


TABLE 10. Wells drilled per million barrels of reserves found.

Average 1935—37	New reserves found[1] (mill. bbl) 1,637	Wells drilled per million bbl: All wildcats 1.2	Wildcat and development dry holes 3.4	All exploratory wells 3.5	All wells drilled[2] 15.9
1945	1,581	2.6	4.8	5.1	15.8
1946	1,635	2.8	5.3	5.7	16.8
1947	1,892	2.8	5.1	5.5	16.4
1948	2,270	2.8	4.8	5.2	16.2
1949	2,798	2.5	4.6	5.0	13.5
1950	2,382	3.4	6.3	6.8	17.6
1951p	3,101	3.3	5.5	6.0	13.9
Total 7 years	15,659	2.9	5.3	5.7	15.5

[1] Initial reserves discovered in new fields and by extensions to previously discovered fields.
[2] Excluding service wells.
p Preliminary estimates.



Between 1935 and 1951 reserves discovered in new fields have aggregated 9,650 million barrels, while the total quantity of oil credited to extensions and revisions amounted to 36,666 million barrels. This means that 3.8 bbl of oil was credited to extensions and revisions for each barrel discovered in new fields. During the entire period, despite the growing production requirements, the nation's underground inventory of petroleum liquids reserves was increased by 18,050 million barrels. Revisions in previous estimates definitely belong to the original years of discovery, and should not be credited to the current year. Reserves credited to the year 1951 included revisions in previous estimates aggregating about 2,037 million barrel. Some of this oil was originally discovered as far back as 1943. The writer has for a number of years given careful study to the allocation of revisions to original discovery years, and believes this represents a sound method of appraising year to year results of exploratory effort.

The result of crediting revisions to original discovery years is to increase the reserves inventory. By allocating the 1951 revisions to back years, it is found that the nation's reserves had actually reached a peak of 34,260 million barrels at the close of 1949, whereas original estimates had placed the nation's reserves at 26,854 million barrels. This does not mean that reserves have subsequently declined, since subsequent credits by revisions are expected to effect a substantial upward revision in reserves reported in 1950 and 1951. It is difficult to adequately estimate reserves in place upon initial discovery, and experience has shown that initial estimates have been extremely conservative over a long period of years.

In the last eight years the ratio of ultimate reserves credits to original new field discoveries has been in the order of 4.92 to 1. The peak year was 1942, when the ratio was 8.91 to 1. Oil found in new fields that year was reported at 280,000,000 bbl, but subsequent credits through extensions and revisions increased the ultimate total to 2,297 million barrels. The difference between the total originally credited to the year 1942 of 1,980 million barrels, and the ultimate credit through extensions and revisions of 2,297 million barrels, increased the reserves inventory from 22,383 million barrels to 28,494 million barrels.

The Petroleum Administration for Defense has established a drilling program calling for 25,000 wells in the last half of 1952, or a rate of 50,000 wells a year, and the completion of 55,000 wells in 1953. This is deemed necessary to provide capacity needed to meet normal requirements this year and next year. The goal calls for a maximum efficient level of 7,278,000 bbl daily, compared with 6,783,000 bbl daily in 1951. While the program is feasible from the standpoint of physical ability, it is obvious that its accomplishment will depend largely upon income incentives, and the retention of the 27½ per cent depletion allowance in the oil operators' income tax returns.

The outlook during the next five years indicates a cumulative increase in world demand for oil of about 27 per cent. The United States is producing 8 per cent of her proved reserves annually, and this rate of withdrawals can be maintained only by the replacement of reserves through intensive, uninterrupted exploration. Every oil well represents a declining asset from the day of its discovery, and must, of necessity, be supplemented by new wells to maintain productive requirements. Likewise, every oil field, when it has reached its peak development, begins to decline in productivity, and must be supplemented by the discovery and development of new sources of oil supply.

The facts presented here provide ample evidence of the oil industry's need for higher crude oil prices, and the more than ample justification for the depletion allowance. The oil industry has proved, beyond any doubt, that it can and will find and develop new sources of oil supply as they are needed, even in the face of many obstacles. Yet, the facts indicate that oil is becoming harder to find each year, and involves expenditures that are made possible only through adequate financial returns on invested capital, and the provisions of the depletion allowance.

Taxes take nearly one-half of the income from oil, and contribute nothing to the maintenance of the industry's productive facilities. Adequate income is vital to the petroleum industry's continued welfare and growth, which depends to an increasing degree upon the reinvestment of earned and borrowed capital. * * *

TABLE 11. Petroleum liquids reserves, discoveries, and production. (Millions of barrels)

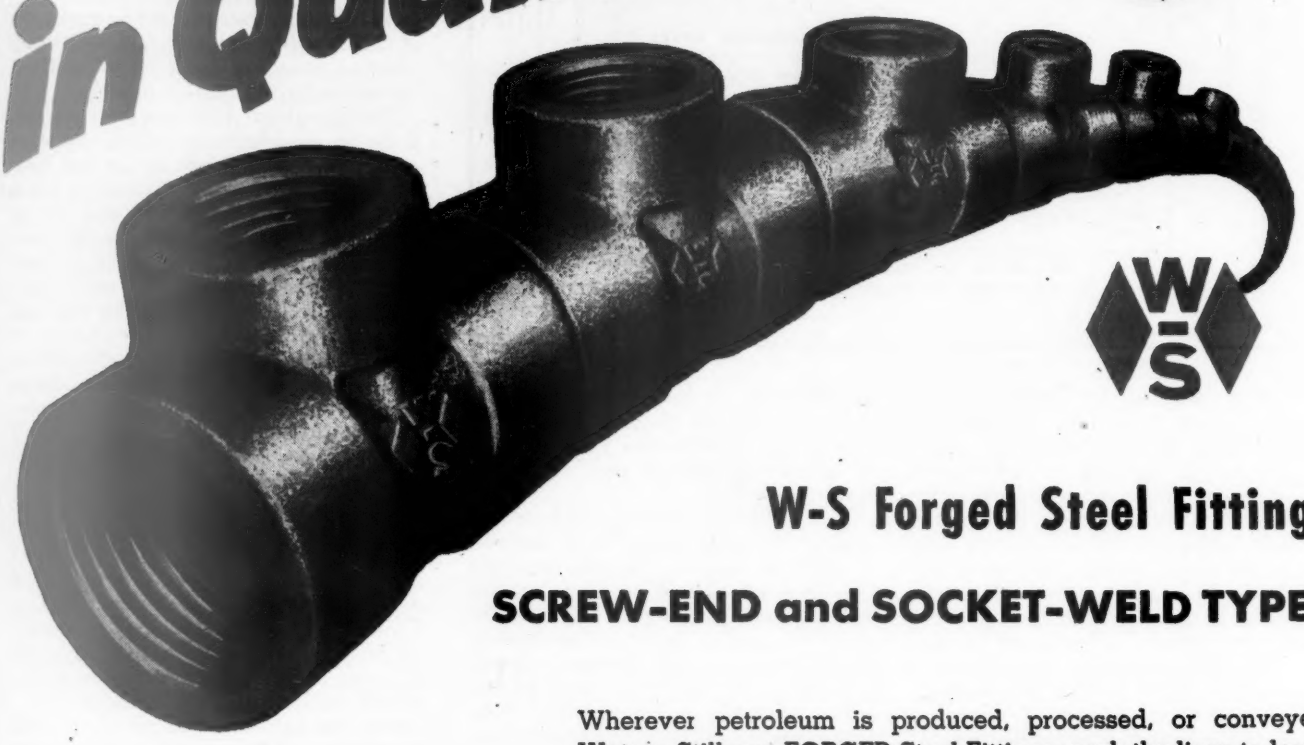
Year	Reserves beginning of year	New pools discoveries	Extensions and revisions	Total oil added	Production	Net increase	Allocation of extensions and revisions	Ultimate reserves credited to original discoveries	Adjusted reserves end of year	Ratio ultimate credits to original discoveries
1935.....	14,243	955	330	1,285	1,036	249	1,620	2,575	19,506	2.70
1936.....	14,492	860	950	1,810	1,142	668	1,988	2,848	21,212	3.31
1937.....	15,160	940	2,850	3,790	1,328	2,462	1,878	2,818	22,702	3.00
1938.....	17,622	825	2,325	3,150	1,265	1,885	2,373	3,198	24,635	3.88
1939.....	19,507	360	2,140	2,500	1,317	1,183	2,042	2,402	25,720	6.67
1940.....	20,690	315	1,685	2,000	1,409	591	2,162	2,477	26,788	7.86
1941.....	21,281	455	1,620	2,075	1,483	592	1,907	2,362	27,667	5.19
1942.....	21,873	280	1,700	1,980	1,470	510	2,017	2,297	28,494	8.91
1943.....	22,383	345	1,265	1,610	1,594	16	2,425	2,770	29,670	8.03
1944.....	22,399	515	1,574	2,089	1,778	311	2,478	2,993	30,885	5.81
1945.....	22,710	440	1,870	2,310	1,836	474	2,566	3,006	32,055	6.81
1946.....	23,184	323	2,370	2,693	1,850	843	2,391	2,714	32,919	8.40
1947.....	24,027	505	2,211	2,716	1,988	728	2,473	2,978	33,909	5.89
1948.....	24,755	461	3,805	4,266	2,167	2,099	1,767	2,228	33,970	4.83
1949.....	26,854	983	2,592	3,575	1,999	1,576	1,306	2,289	34,260	2.33
1950.....	28,430	623	2,706	3,329	2,154	1,175	1,036	1,659	33,469	2.66
1951p.....	29,605	465	4,673	5,138	2,450	2,688	—	1,274*	32,293	2.74
1952p.....	32,293									
Total...	—	9,650	36,666	46,316	28,266	18,050	32,429	42,888	—	4.44[1]

* To balance proved reserves December 31, 1951. (p) Preliminary estimates.

[1] Average 8 years, 1943—50, is 4.92 times initial discoveries credits.

Source of original data:—Joint Committee on Petroleum Reserves of The American Petroleum Institute and American Gas Association. Slight differences are due to author's revisions and interpolations of credits for natural gas liquids reserves and discoveries.

Quality... in Quantity



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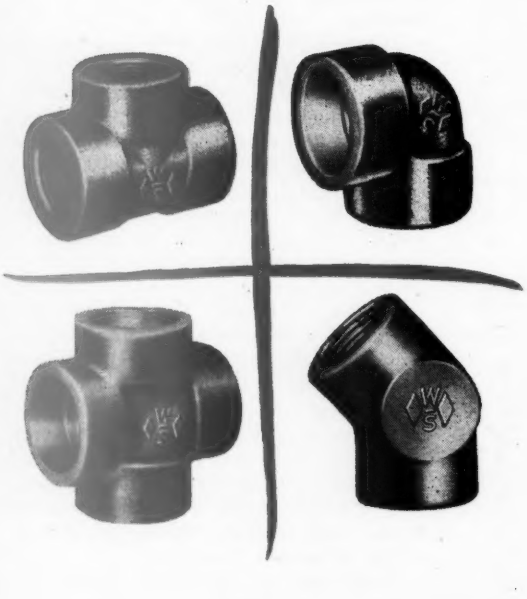

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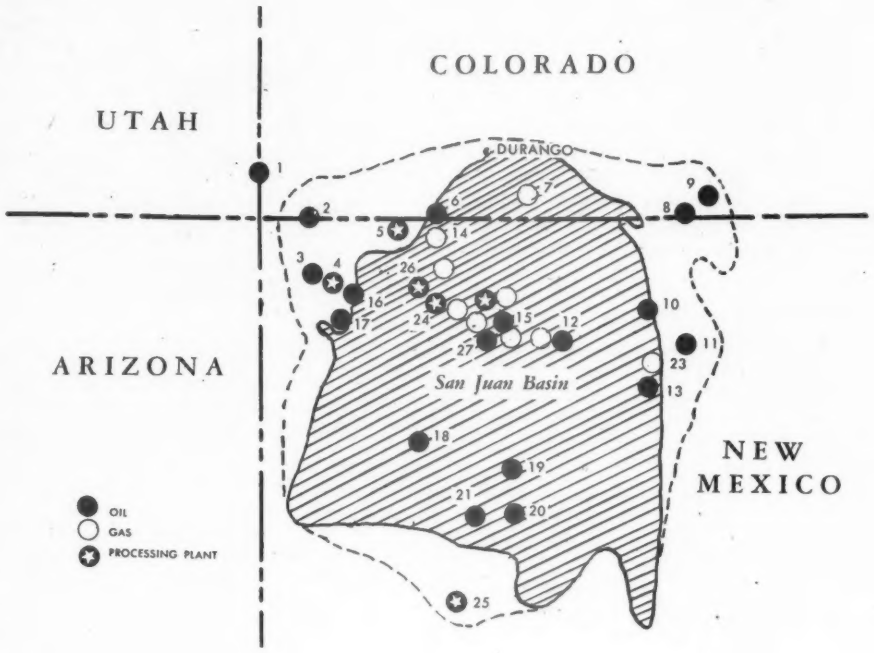


LEGEND

Fields and refineries and gasoline plants

1. Hovenweep
2. Mancos
3. Rattlesnake
4. Rattlesnake plant
5. Barker plant
6. Red Mesa
7. Ignacio
8. Chromo
9. Price-Gramps
10. Dulce
11. Mission
12. Doswell
13. Lindrith
14. Ute Dome
15. Kutz Canyon—Fulcher Basin
16. Hogback
17. Table Mesa
18. Stoney Buttes
19. Red Mountain
20. Hospah
21. Seven Lakes
23. Gavilan
24. Farmington Refinery
25. Prewitt Refinery
26. San Juan
27. Stanolind-Huerfano unit

AREA OF PROMISE!

The San Juan—*New Basin of Wealth!*

First oil and later gas are found—now processing plants are built and huge pipe lines carry fuel to far cities

SHERMAN A. WENGERD

THE Four Corners Region embraces northeastern Arizona, southwestern Colorado, northwestern New Mexico, and southeastern Utah surrounding the point common to the four states. (See Paleotectonic map.) The region is bounded on the northeast by the San Juan Mountains; on the east by the Nacimiento Mountains; on the southeast by the Rio Grande trench and the Mt. Taylor volcanic complex; on the south by the Zuni Mountains in New Mexico and the Apache-Holbrook arch in Arizona; on the west by the Kaibab-Coconino uplift in Arizona and the Cordilleran trench in western Utah; on the northwest by the Wasatch Plateau, and the Uinta Basin in Utah. The region encompasses numerous laccolithic mountain masses, deep-seated and exposed granite ridges, three major bowl-shaped sedimentary basins, and a vast arcuate shelf on the west, southwest, and south sides of the Uncompahgre-San Luis-Nacimiento highland, which is a part of the Colorado Mountains ("Ancestral Rockies"—Lee) of Pennsylvanian age. Regionally the Four Corner petroliferous province encompasses virtually the entire Colorado Plateau physiographic province and the southern extensions of the Southern Rocky Mountains. The San Juan Basin covers the southeastern part of this region and is one of utmost stratigraphic and structural complexity. (See Structural Elements map). Its petroleum potential is greater than past productive history would indicate. (See Correlation-Nomenclature chart).

EXCLUSIVE

Sources of Information

The published bibliography is extensive and detailed as to the stratigraphy and structure of the Four Corners Region. These published data, utilized as background material, include bulletins and professional papers by the U. S. Geological Survey, State Geological Survey bulletins, field trip guidebooks, and articles from the geological bulletins and journals. Unpublished sources include reports by consulting geologists, and conferences with most of the petroleum geologists intimately acquainted

with the region. A partial bibliography covering petroleum and exploratory developments of the San Juan Basin is given at the end of this generalized paper.

Regional Geology

Stratigraphy. Ordovician, Silurian, late Permian, and early Cretaceous rocks are conspicious by their virtual absence in the region. (See stratigraphic column). Additional research, however, may reveal the presence of Comanchean (early Cretaceous) rocks in northwestern-most New Mexico and southeastern-most Utah. All other Paleozoic systems are represented by marine strata (considered to be shelf sediments related to the south end of the Cordilleran geosyncline in western Utah and Nevada), and continental sediments of Permian age.

Interbedded with the marine strata of Cambrian, Devonian, Mississippian, and Pennsylvanian age *below*, and the upper Cretaceous marine strata *above*, are continental sandstone, siltstone, shale, fresh-water limestone, and gypsum of Triassic and Jurassic age. The well-known Jurassic Sundance tongue of marine sediments to the north may be correlative with the lagoonal sediments of the Todilto formation in the San Juan Basin.

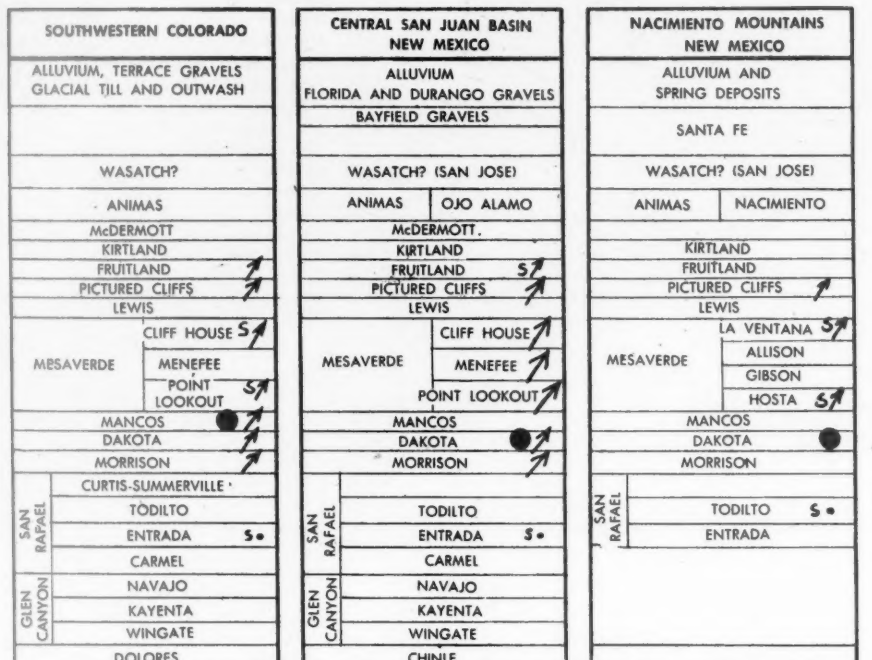
The latest marine invasion of the Four Corners Region, which occurred from the northeast during late Cretaceous time, is responsible for the deposition of the Lewis shale and the lower Pictured Cliffs sandstone in the San Juan Basin. With the exception of the complex interfingering of Mesaverde continental sediments and marine shales north of the Zuni uplift, the lower part of the upper Cretaceous section of the San Juan Basin is of marine origin. (See Cretaceous stratigraphic cross section).

Latest Cretaceous time is represented by continental sediments containing many coals in the Fruitland-Kirtland formations, with the typical intermontaine deposits of Wasatch-San Jose sandstone and shale of Tertiary age representing the latest widespread sedimentation in the region.

Sources for sediments are numerous throughout the long and involved geologic history of the San Juan Basin, resulting in the predominant deposition of limestone, dolomite, and possibly evaporites during Palezoic time, and the predominant deposition of clastics during Mesozoic time.

Specific Stratigraphic Problems. Transgressive-regressive sediments are characteristic of the Dakota, Mancos, Mesaverde, Lewis, and Pictured Cliffs sequences in the San Juan Basin of New Mexico. Interfingering limestone, shale

CORRELATION—NOMENCLATURE CHART.



After Bradish and Mills

The Author

Sherman A. Wengerd is an associate professor of geology at the University of New Mexico, and a research consultant in petroleum geology. He was formerly a research geologist for Shell Oil Company in the Mid-Continent division. Winner of the President's Award from the AAPG in 1948, Wengerd made a distinguished lecture tour before AAPG Societies on Sedimentation of Majuro Atoll during May of 1950. He is a lieutenant commander in the U. S. Naval Reserve with four years of Naval duty during World War II. He was founder and first commanding officer of Volunteer Naval Research Unit 8-7, Albuquerque, New Mexico. Wengerd, who received his doctorate in geology from Harvard in 1947, is listed in *American Men of Science*, Marquis' *Who's Who in the West*, and *Who Knows and What*.

East flank of the Defiance Uplift, westernmost side of the San Juan Basin. View north from 10,000 ft near Fort Defiance, Arizona.

and sandstone, with sandstone wedging out southwestward into the San Juan Basin characterize the Hermosa-Rico transition to Permian continental sediments. The discovery of oil from Mississippian Leadville limestone in the Table Mesa field, in New Mexico during 1950 has suggested a greater productive potential for this widespread formation. A widespread disconformity on the Mississippian limestones, overlain by the Pennsylvanian Molas shale, makes available important secondary porosity that may eventually be found to be of great economic importance for the accumulation of oil in the Four Corners Region.

Summary. In summary, the stratigraphic section of the San Juan Basin is in every specific locality conducive to the accumulation of oil and gas in from two to six reservoirs. (See correlation-nomenclature chart). Exploration for oil and gas in both stratigraphic and structural traps is complicated not only by the vastness of the region and the paucity of deep tests, but also by stratigraphic complexities induced by major uplifts in Pennsylvanian time, the beginning of Laramide folding in late Cretaceous time, and Tertiary uplift, faulting, regional tilting, and subsidence.

Structure. The San Juan Basin has a complex structural history. Paleozoic uplifts surrounding the region had profound influence on the Paleozoic sediment supply, distribution, and eventual deposition, which, with and without Laramide folding, may have been the prime cause for oil and gas accumulation in older strata. During Mesozoic time, gas sands deposited on monoclines formed as the basin gently subsided, contained porosity variations responsible for the large San Juan gas fields other than those on Ute and Barker Creek domes.

The predominant trend of the Defiance and Nacimiento uplifts is north, whereas the Zuni and Uncompahgre-San Luis uplifts trend northwesterly. On the flanks of all these uplifts, Pennsylvanian strata are thin or absent, with the exception of the south, southwest and west flanks of the Uncompahgre-San Luis-Nacimiento positive arc. Character of these sediments suggest that these ancient Paleozoic uplifts, rejuvenated in the late Cretaceous and Tertiary time, were caused by vertical movements and some local thrusting, rather than large scale Paleozoic subsidence of the basin.

Numerous diverse-trending Laramide anticlines are present in the San Juan Basin. These anticlines are aligned in part parallel to the dominating ancient uplifts, with certain exceptions such as the following:

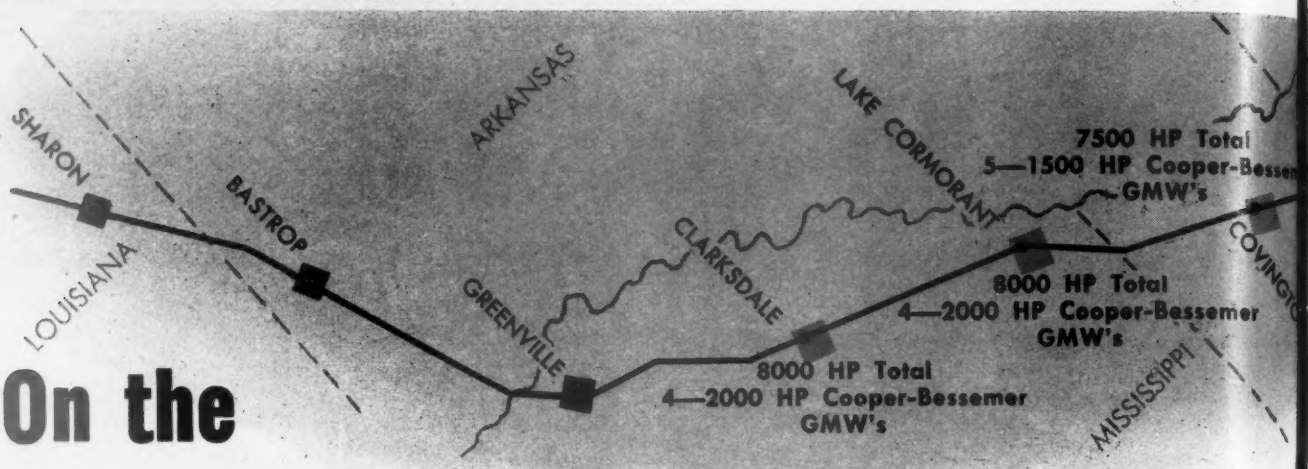
1. Drape and compaction folds on the Chaco slope, south flank of the San Juan Basin.
2. Anticlines radial to the Tertiary San Juan Uplift on the north rim of the San Juan Basin.

Although faulting does not appear to be an important control in the accumulation of oil and gas in the San Juan Basin, this Basin is notably faulted by thrust slices on the east rim, and short normal faults on the south flank.

In summary, differential subsidence beginning strongly in Cretaceous time, with some east-west directed compressive stresses, and notable divergences caused by nearby ancient uplifts, are thought to be the causes of most of the smaller anticlines in the San Juan Basin.

Geologic History

San Juan Basin and Southwestern Colorado. The San Juan Basin, with its northeast extension, the Chama Basin, covers virtually all of northwestern New Mexico and a part of southwestern Colorado. The Basin is bounded on the south by the Zuni Uplift and Mt. Taylor volcanic area; on the west by the Defiance Uplift; on the northwest by the Four Corner Platform and the Paradox



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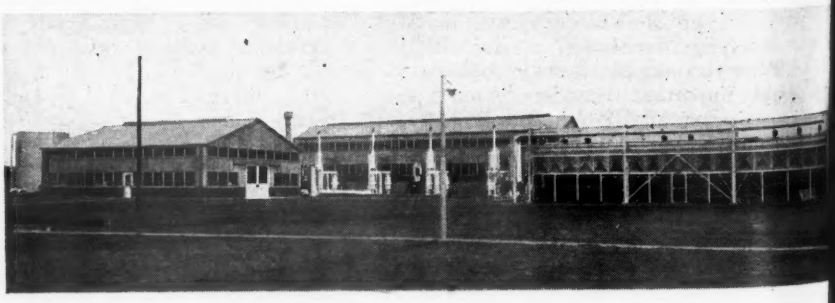
Jeffersontown station of Texas Gas Transmission's main line, showing compressor building in middle background.



ANGLE

Compressors

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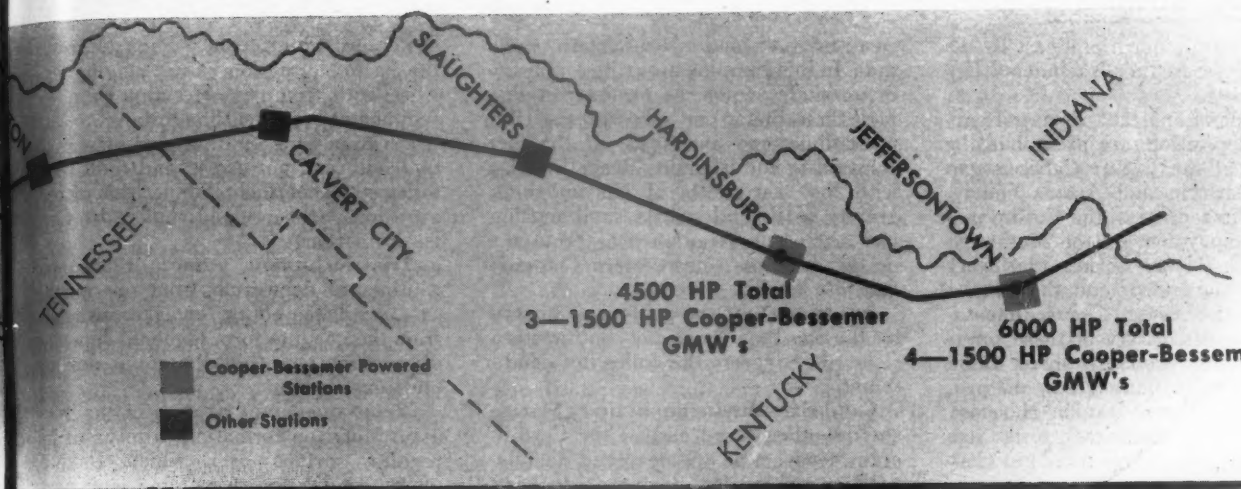
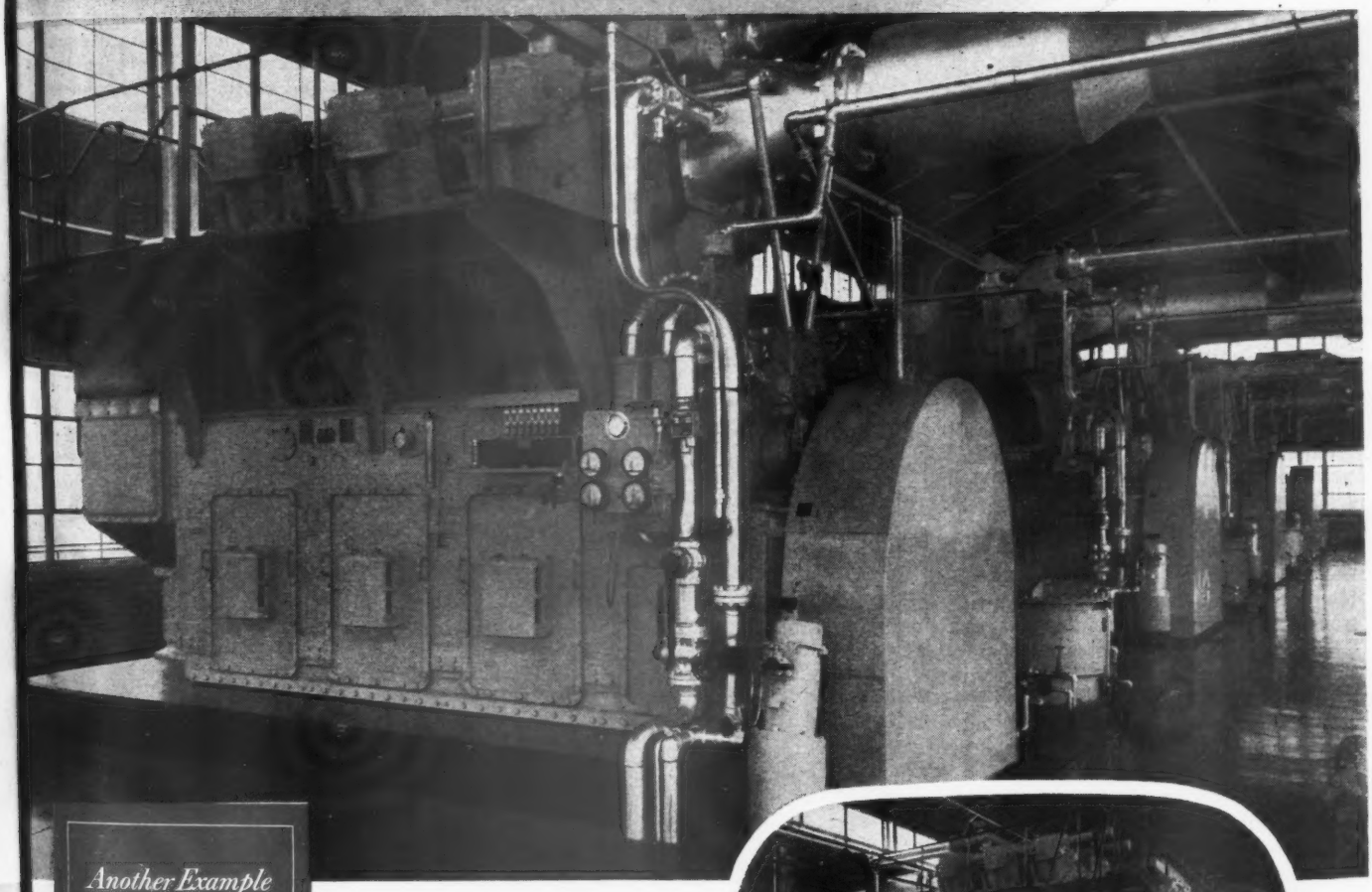
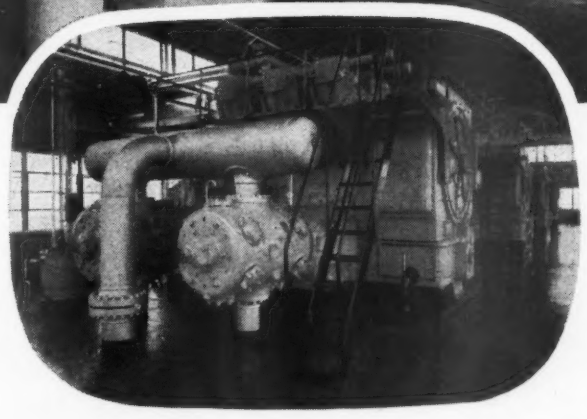
San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.





Another Example of Efficient Power at Lower Cost

Line-up of four big, modern Cooper-Bessemer GMW units in Texas Gas Transmission Corporation's Jeffersontown station. These are 6-cylinder GMW's rated 1500 hp each.



Same GMW units as above but shown here from compressor cylinder side.

Cooper-Bessemer

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Tulsa Shreveport St. Louis Los Angeles Chicago Caracas, Venezuela

Basin, and on the north and east by the Uncompahgre-San Luis-Nacimiento Uplift.

Four gaps, important during Pennsylvanian deposition, are present in the uplift ring of the Basin: Cabezon gap (Puerco platform and Acoma embayment) on the southeast, the Gallup gap and Zuni empayment on the southwest, the Shiprock (Four Corner platform) gap on the northwest, and the Chama gap on the northeast. The sedimentational and uplift history of these interuplift gaps will probably prove to be very important in finding new oil production in the Pennsylvanian Hermosa formation, once sufficient tests are drilled to suggest porous trends in clastic-black shale interfingers on the northeast, east, and southeast.

The geographically-continuous Uncompahgre-San Luis-Nacimiento Uplift was initiated in Pennsylvanian time, probably during the Wichita orogeny. This uplift limited marine sedimentation to the north and east, but was high enough to supply abundant granite wash and quartz sands to marine Hermosa seas on the south and west in the gently subsiding basin. Similar clastics were shed westward in Colorado into the Paradox black shale-evaporite basin. The Zuni uplift on the south and the Defiance uplift on the west stood very low in the Hermosa seas, apparently barely breaking water during most of Hermosa time (Atoka, Des Moines, and Missouri). As a consequence, the Pennsylvanian sections on the south part of Chaco slope (north of the Zuni uplift) and on the western-most part of the east Defiance shelf are limy red shales with few pure limestones or porous sandstones. At the north end and on the eastern break of slope of this east Defiance shelf, extending from the Four Corners gap around the basinward side of the Chaco slope, porous dolomite and limestone trends will very likely be found in Hermosa strata.

One deep test in the Cabezon gap area on the southeast between the south end of the Nacimiento Mountains and the southeast end of the Zuni Mountains proves the existence of the Cabezon gap by the presence of thick interbedded Hermosa limestone, sandstone, and dark gray shale, similar to the section on the Lucero uplift, 30 miles to the south. This can only mean that the Hermosa sea in the San Juan Basin, even during its greater Pennsylvanian subsidence, had an access way to the southeast into the Sandia and Lucero basins south and east of Cabezon gap.

On the northeast through the Chama gap, only narrow connections were established with the Chama basin and the Sangre de Cristo basin which lay to the east. For this reason the Pennsylvanian section here is thinner, filled with clastics, and discontinuous in its disposition.

The northwest access way (Shiprock gap) for Pennsylvanian seas is intimately related to oscillations of the Four Corners platform and the south end of the Paradox evaporite basin in southeastern Utah and southwestern Colorado. In this complex area, the evaporite-black shale sequences of the Paradox facies interfinger not only with the Hermosa limestone and shale of the San Juan Basin and Blanding Basin, but also with the vast sheets of Uncompahgre granite wash and quartz sand moving into the Pennsylvanian seas from the northeast across southwestern Colorado and into Utah.

A summary of the geological history for the San Juan Basin and southwestern Colorado suggests the following conditions:

Cambrian-Mississippian time. Marine shelf southeast and east of the Cordilleran geosyncline. Widespread non-deposition or erosion during Ordovician and Silurian time, followed by Devonian-Mississippian limy seas, thence widespread regional uplift.

Pennsylvanian time: Subsidence of the basin, formation of the ringing uplifts, with complex Hermosa-Paradox sedimentation as outlined above.

Permian time: Withdrawal of seas to the southeast, northwest, and southwest followed by continental deposition of red sandstone, siltsone, and shale (the Cutler formation).

Triassic-Jurassic time: Continued continental deposition from the northeast, with temporary marine invasion from the north to form lagoonal deposits of gypsum and thin limestone during mid-Jurassic time.

Cretaceous time: Erosion of the Jurassic Morrison formation to form an irregular surface over which Dakota quartz sands were spread and later partially reworked by the invading Mancos sea of the Rocky Mountain geosyncline on the east and north. The Mancos seas

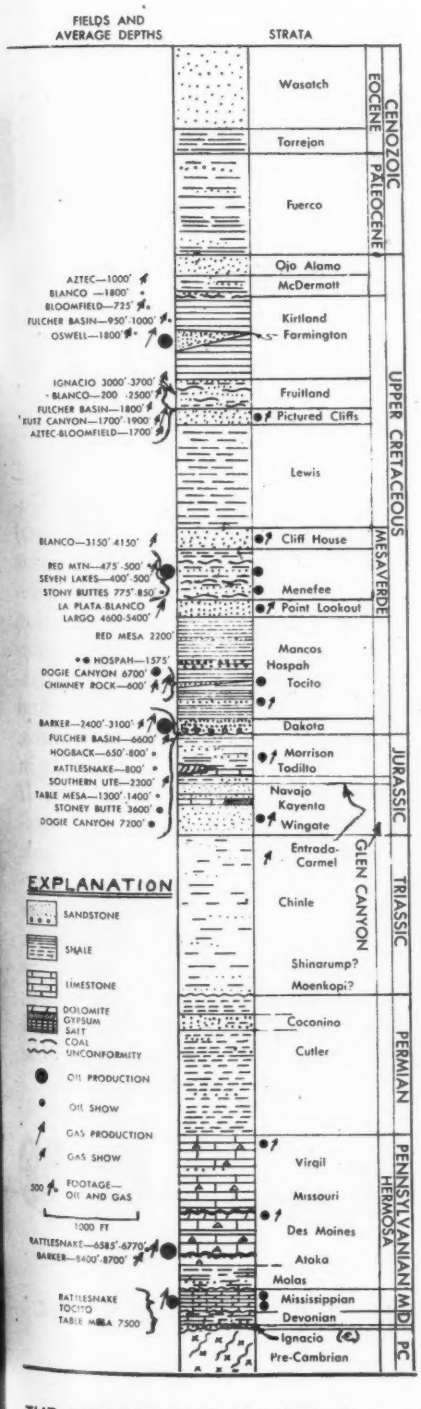
PALEOTECTONIC MAP—FOUR CORNERS REGION.

of the San Juan Basin were continually invaded by clayey quartz sands from the Meso-Cordilleran geanticline of which the Zuni-Defiance uplifts became an integral part during late Cretaceous time. Thus many continental and littoral sandstones lie interbedded with organically-rich Mancos and Lewis shales (Mesaverde and Pictured Cliffs sandstone) in the south, southwest, and west sectors of the Basin. In latest Cretaceous time the seas withdrew, and coal swamps were formed, later to be flooded by Tertiary continental quartz sand, silt, clay and volcanic ash of great thickness.

Tertiary time: Continental deposition on wide flood plains formed blanket shales and sandstones of Tertiary age, *during* and *after* the Laramide orogeny, which rejuvenated the ringing uplifts and formed moderate folds within the Basin itself. The latest Tertiary activity was volcanism, which formed plugs, flows, and dikes of basalt.

The San Juan Basin contains a maximum sedimentary section totalling 15,000 ft in thickness. The stratigraphic section in southwestern Colorado totals at least 9000 ft at a maximum, excepting where abnormal thicknesses due to salt intrusion are encountered. Continuous late Cretaceous and Tertiary uplift to an average elevation of 6500 ft despite strong differential San Juan Basin subsidence is responsible for the early withdrawal of the seas. The Colorado Plateau block, however, was protected from intricate folding and faulting, such as that which took place in the Rocky Mountains. The stratigraphic section thus contains many unconformities, transgressive-regressive strata in both Pennsylvanian and Cretaceous sequences, and thick marine shales and limestones; all conducive to the origin, migration, and entrapment of oil and gas.

STRATIGRAPHIC COLUMN



Productive Fields

Kutz Canyon-Fulcher Basin—Blanco Area. In this area there is production of oil from the shallow Farmington sandstone in Bloomfield, Oswell, and Wyper fields; sweet gas from the Pictured Cliffs sandstone in the Fulcher Basin-Kutz Canyon trend and associated lesser trends; sweet gas from the Point Lookout and Cliffhouse sandstones in the La Plata-Blanco-Largo trend, and oil from the Dakota sandstone in the single well Angels Peak field (Byrd-Frost, Hargrave No. 1, Section 4, T27N, R10W). This area is situated in the northwest central San Juan Basin. (See map of fields and important wildcats.)

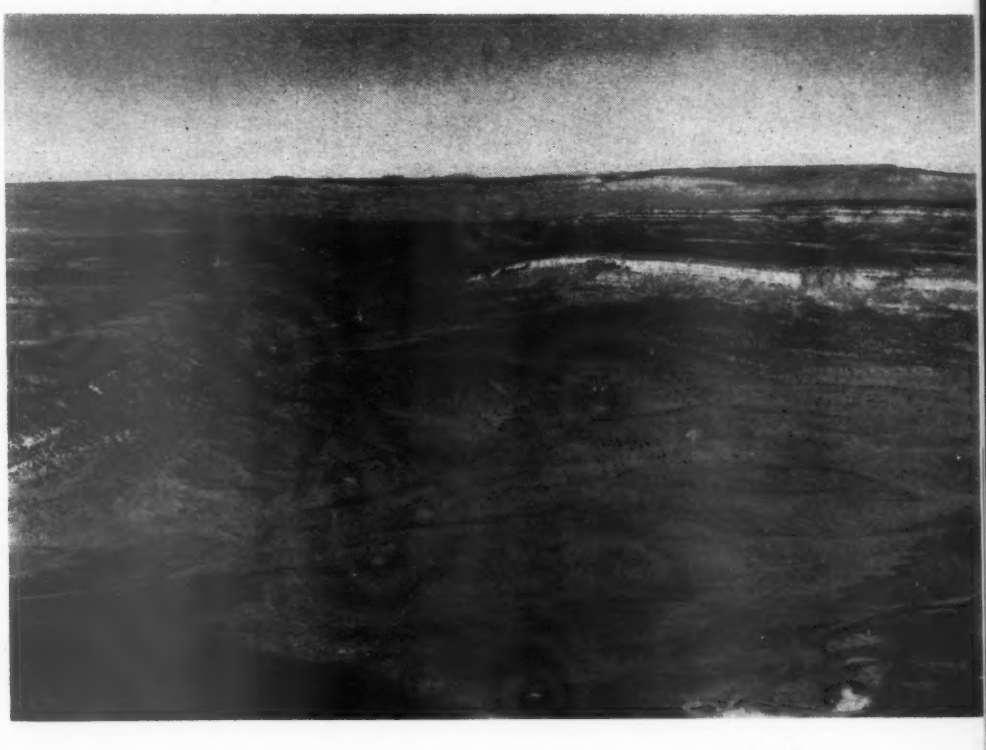
The significant fact about this area is that all production comes from stratigraphic traps on a simple unfaulted monocline, which is the regional dip of the San Juan Basin.

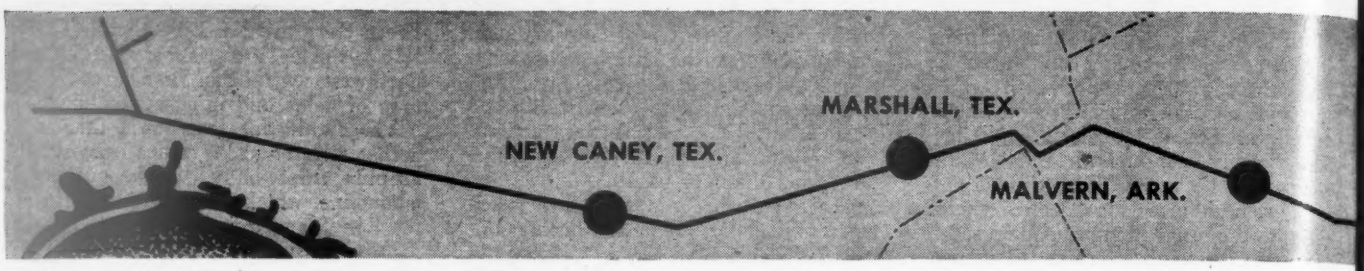
Stoney Buttes-Hospah Trend. This area contains Stoney Buttes, Seven Lakes, Red Mountain, and Hospah fields, all productive from stray Mesaverde sandstones named the Hosta and Hospah sands, on small anticlines having low closure, but lying athwart an important trend of stratigraphic entrapment of oil, free of gas. This area, similar to the Shiprock area is characterized by active water drives of fresh water from the outcrops, and brines from the deeper part of the Basin. The only fields yet found to be important in this trend are Hospah field, productive of oil from Mesaverde sandstone, and the Stoney Butte field, productive of oil from the Dakota sandstone.

Shiprock Area. This area contains Hogback, Rattlesnake, Table Mesa, Ute, and Barker Creek fields on the west flank of the San Juan Basin, and on the Four Corners platform.

These fields are all situated on prominent anticlines that can be mapped from surface outcrops. With the exception of two wells that produced about 500,000 bbl of oil from Hermosa strata in Rattlesnake field, the deep Hermosa sour gas production in Barker Creek and Ute Domes, and the recent Continental discovery of deep oil from Leadville limestone in Table Mesa field, all gas and oil production is from the Dakota sandstone.

Northwest plunge of the Zuni Uplift, southwestern San Juan Basin. (See maps.) View north from 8600 ft. Chuska Mountains in the background.





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25 2000-horsepower engine compressors used in 5 stations on 1400-mile line

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The uniflo UTC-16 is built in sizes from 1000 to 2000 hp. If your process requires gas compression and you have a suitable gas available for fuel, the Worthington UTC-16 will do a better job for you. Contact your nearest Worthington District Office or write Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Engine Sales Division, Buffalo, N. Y.

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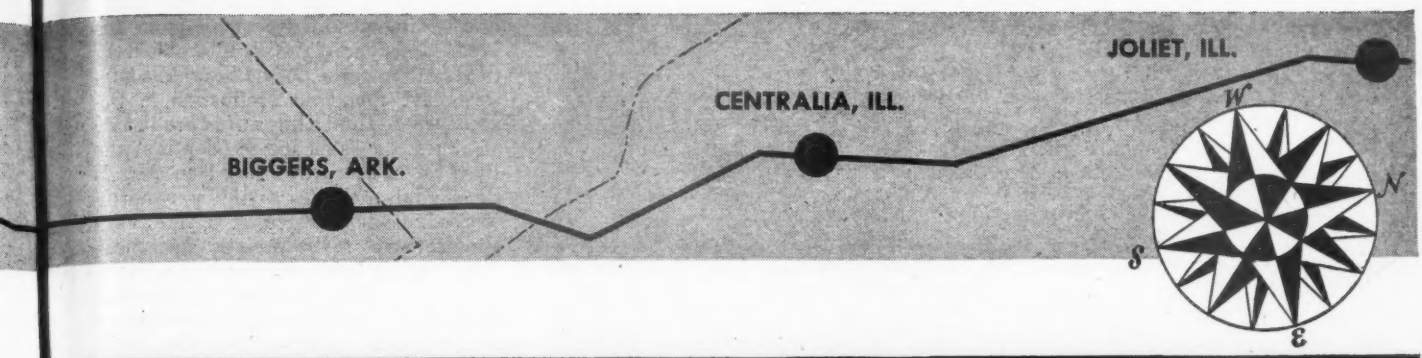

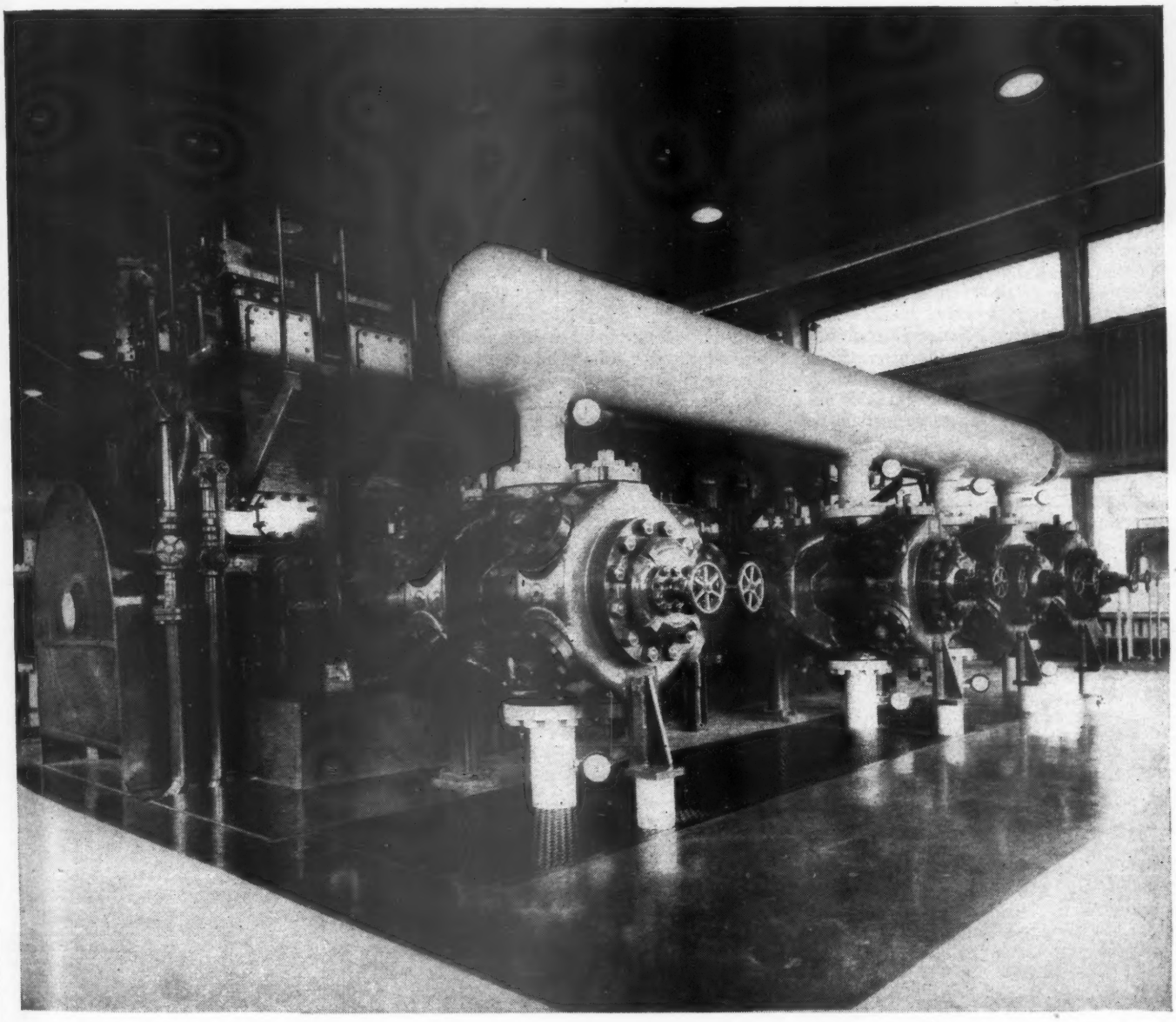

WORTHINGTON 2000-hp 10-CYLINDER ENGINE-COMPRESSORS at New Caney, Texas, station of the new Gulf Coast-Chicago pipeline of the Texas-Illinois Natural Gas Pipeline Company. These engines use Worthington's uniflo thru-scavenging system — a design thoroughly proved by years of research by Worthington.

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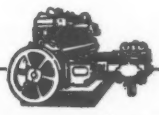
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Chacra sandstone, uppermost Mesaverde, on the Chaco slope, south flank of the San Juan Basin just north of Hospah field. View northwest from 8000 ft.

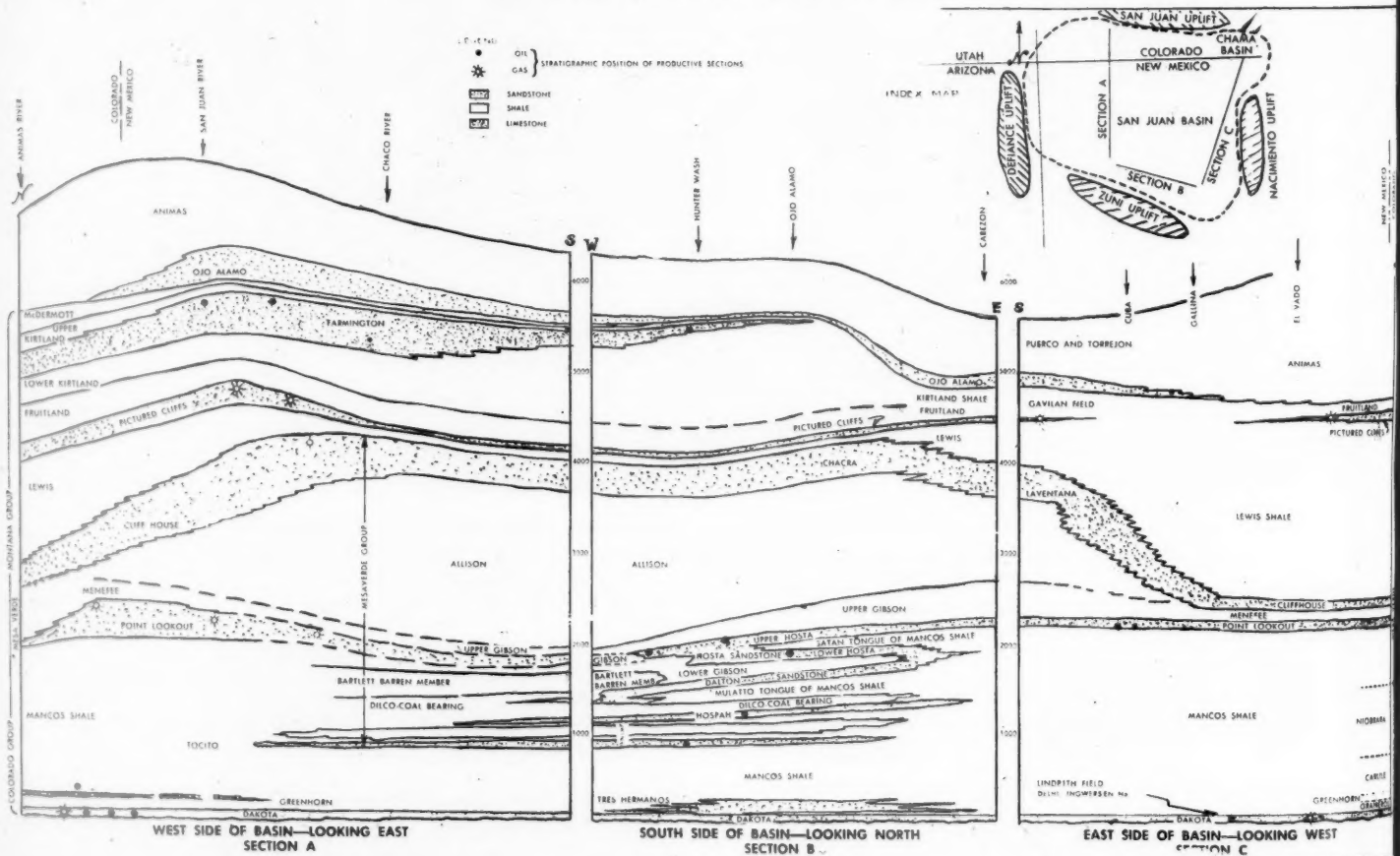
Gavilan-Lindrith Area. Stratigraphic entrapment of gas in Pictured Cliffs sandstone characterizes the Gavilan field, with probable stratigraphic entrapment of oil in Dakota sandstone in the Lindrith field.

Both these fields were discovered in 1949 but enough has been learned about the Pictured Cliffs sandstone to pronounce it stratigraphic entrapment, as no subsurface or surface anticlines are represented in the shallow beds in that area. The Lindrith field (Delhi, Ingwersen No. 1), however, with one deep test drilled and productive of oil from Dakota sandstone, is still a problem as two similar tests northeast and southwest have found no production in Dakota strata. The Delhi well is productive at almost the same sub-sea depth as the Byrd-Frost, Hargrave No. 1 in Angels Peak field, 45 miles to the west-northwest. Since no surface or seismic anticline appears to be present in or near the Lindrith field, one could project a narrow stratigraphic trend of potential Dakota oil production north-northeast and possibly southwest of the Delhi well. The drilling of additional tests will prove or disprove this idea.

Chromo-Gramps Price Area. These anticlinal fields are productive of oil from fractured Mancos shale and the Dakota sandstone on prominent anticlines. Both of these fields are "freak" fields in that every other anticline in the area has been found utterly barren of oil or gas in commercial quantities. This area is located in the northeast, Chama, reentrant of the San Juan Basin.

Dogie Canyon Area. The discovery well in this field was drilled in 1951 and had an initial potential of 400 bbl of sweet oil per day from a stratigraphic entrapment in the Tocito sandstone at 6700 ft. Almost equivalent production was found in the second well and the cumulative production for these two wells has been 65,000 bbl in 6 months. The oil is hauled to a refinery at Prew-

CRETACEOUS STRATIGRAPHIC CROSS SECTION

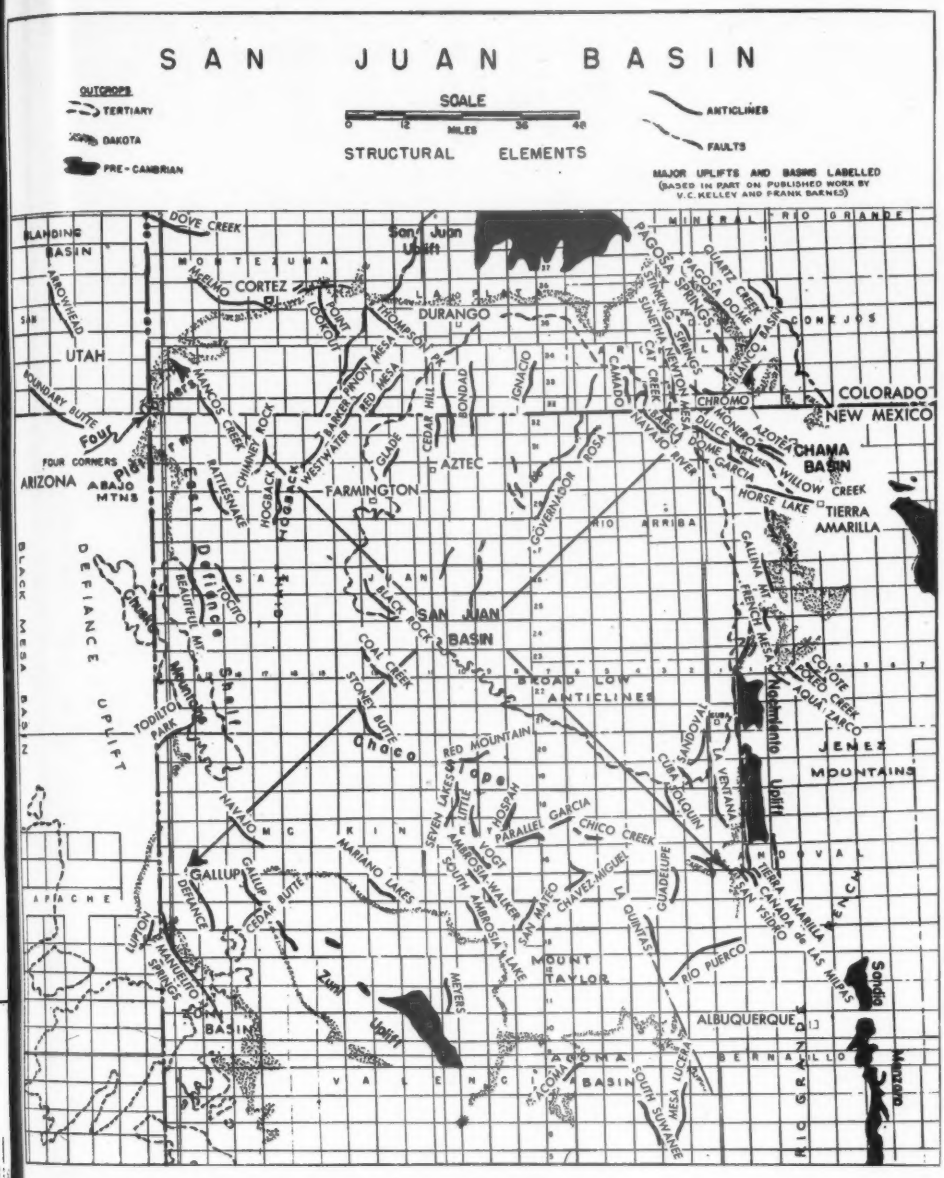


WEST SIDE OF BASIN—LOOKING EAST
SECTION A

SOUTH SIDE OF BASIN—LOOKING NORTH
SECTION B

EAST SIDE OF BASIN—LOOKING WEST
SECTION C

After Sears, Dane, Hunt, Hoover



STRUCTURAL ELEMENTS OF THE SAN JUAN BASIN

itt, New Mexico. Until a refinery is built nearby, or a pipe line laid, the full productive potential of this field will not be known. Discovery of oil from this stray Mancos sandstone has opened up a wide new region for exploration in the San Juan Basin. This field is also productive of Pictured Cliffs gas and Dakota-Morrison gas which are shut-in.

Ignacio Field. This field, rapidly being extended in all directions, was discovered by Stanolind in 1950, with gas production now proved from Fruitland, Pictured Cliffs, and Dakota-Morrison sandstones. Although considered to be an anticlinal accumulation with an active water drive in the uppermost sandstones, the porosity trend concerned appears to lie on a regional east-west strike, and further accumulations of this type will no doubt be made.

Reserves

Gas. The major ace-in-the-hole for the San Juan Basin is the very important Pictured Cliffs-Mesaverde gas potential of the Blanco-Kutz Canyon-Fulcher Basin area. Production data to date indicate a per-acre-recovery of 13 to 17,000,000 cu ft of sweet gas per acre from the shallow Pictured Cliffs sandstone on the west flank of the San Juan Basin. Based on average porosity of 9 per cent, average thickness of 60 ft, abandonment pressure of 100 psi, initial reservoir pressure of 600 psi, and the presently extended limits of the Kutz Canyon-Fulcher Basin gas field, the total ultimate recovery of gas may be over 150 billion cubic feet, with the productive life for each well being about 15 years at the present rate of withdrawal. Initial potentials in the field range from 500,000 to 2,500,000 cu ft of gas per day, although West Kutz Canyon field has shown single well potentials up to 6,400,000 cu ft of gas per day. Production allowable of 25 per cent of the initial potential under present regulations has never been enforced in the area. Oil and gas laws of New Mexico require ratable-take from any well drilled within a productive field boundary.

The Blanco field, a Mesaverde porosity-variation reservoir, has a computed ultimate recovery of 29,000,000 to 59,000,000 cu ft of gas per acre, depending upon variations in initial data and in computation. Since all newly drilled wells in the field have only recently been tied into gathering lines upon completion, no long-range production data are available. The former lack of outlet was remedied late in 1951 with completion of the California Pipeline by the El Paso Natural Gas Company.

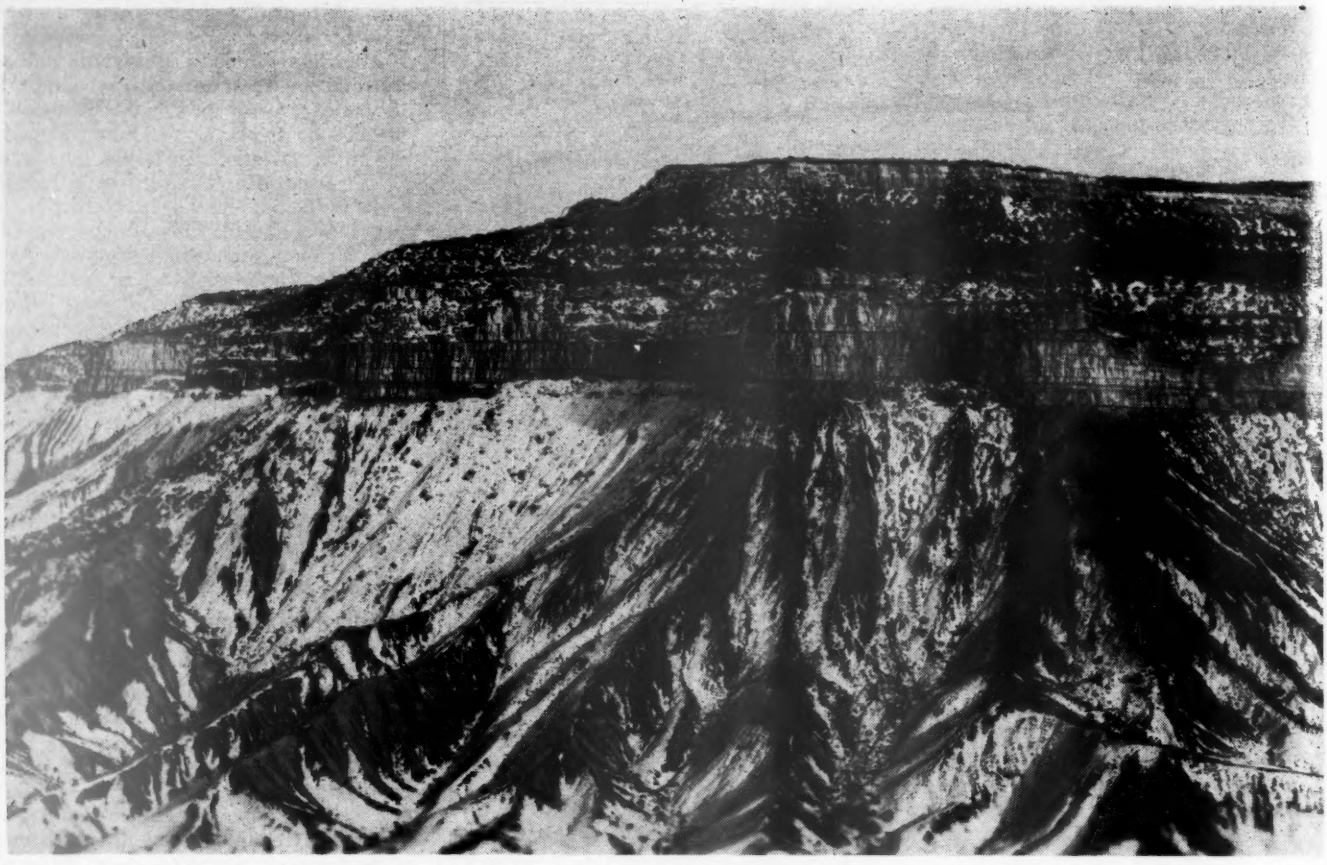
The Barker Creek and Ute dome gas fields, productive of sweet gas from Dakota sandstone and sour gas from the Paradox facies of the Hermosa limestone of Pennsylvanian age, have a tremendous gas potential that cannot be computed with any degree of accuracy owing to lack of core data, and the lack of limits to the fields. It may be anticipated, however, that the present rate of withdrawal from these fields will result in a rapid pressure drop, and the true nature of the reservoir can be appraised only after two years of steady flush production. These two fields appear to be structural accumulations, whereas the Mesaverde and Pictured Cliffs fields lie in stratigraphic traps.

Total gas potential of the San Juan Basin was thought to be three trillion cubic feet only four years ago. Wildcat discoveries, extension of fields, and an increased recognition of the blanket characteristic of the Cretaceous sandstones in the San Juan Basin now lead even the most conservative geologists and engineers to predict an ultimate recovery of gas ranging from 20 to 30 trillion cubic feet. These data indicate the existence of one of the large gas reserves in the United States, a reserve that is now undergoing full exploratory and productive development.

Oil. Production has been obtained in the San Juan Basin since 1911 when Seven Lakes field was discovered by Henry Brock and Jerry Farris in McKinley County. This Mesaverde oil field on the south side of San Juan Basin stirred little interest because it cost four dollars per barrel to haul the oil to Gallup by wagon and these early operators were paid just four dollars per barrel.* Oil production was increased with discovery of Dakota oil in the Hogback field in 1922. A minor boom resulted from discovery of Rattlesnake and Table Mesa fields. In 1935, Gramps-Price field was discovered; in 1944 Stanolind Oil and Gas Company began the first concentrated effort to lease immense areas after utilizing every possible means of exploration. Stanolind's exploration proceeds today, and this company, El Paso Natural Gas, Byrd-Frost, Delhi, and Southern Union have the strongest acreage position in the San Juan Basin.

Discovery of Morrison-Dakota gas on Ignacio anticline in La Plata County by Stanolind, and Leadville oil in Table Mesa field in San Juan County by Con-

*Personal communication of Jerry Farris, February, 1949.



Mesaverde section lying on Mancos shale in the northwest spur of Mesaverde National Park, Colorado; northwestern San Juan Basin. View east from 7500 ft. This section produces gas in the Blanco trend 50 miles to the southeast.

tinental have provided a notable spurt in the search for oil in the entire north half of the San Juan Basin.

Production of oil to date for an area the size of the San Juan Basin has been disappointing; but it should be remembered that the following summary is probably true:

Tests to Pictured Cliffs ss	35 per cent of area
Tests to Mesaverde ss	20 per cent of area
Tests to Dakota ss	5 per cent of area
Tests to Hermosa fm.	1 per cent of area or less
Tests to Pre-Penn. strata	½ per cent of area or less

This summary is based on the theory of probabilities for a normal sedimentary basin. The area is indeed virtually untested, but the ratio of rank wildcat discoveries in the Dakota sandstone to rank wildcats drilled is quite low, whereas the ratio of Mesaverde wildcat discoveries to wildcats drilled is quite high.

The general reserve picture for oil within discovered fields is not good owing to their long productive history, but subsequent pages will indicate certain extensions of trends which will no doubt yield abundant new oil production. Calculations of reserves for San Juan oil are at present little better than guesses, unless each field is considered individually and some ratio of discovery projected to both extension and rank wildcat discoveries. At the moment, in view of the rank wildcat discovery of Tocito oil in the Dogie Canyon field by the Doswell interests, it is sufficient to state that the San Juan Basin still has a high potential for Cretaceous oil, and the discovery of deep oil in Table Mesa field opens up a wide area for deep Hermosa and Leadville exploration in the northwest sector of the Basin. Only the utilization of the best geologic thought and stratigraphic analysis will enable one to delimit areas, purchase acreage, and drill tests at the lowest risk investment.

Exploratory Techniques

All means of petroleum exploration have been and are being tried in the San Juan Basin, including doodle bugs and witch sticks.

Surface geologic mapping. This direct and inexpensive means of geologic exploration has been found highly effective in locating anticlines on the flanks of the Basin wherever Ojo Alamo to Mesaverde beds outcrop, and in the broad band of outcrops between the Dakota sandstone and Permian rocks. Detailed work in Mancos shale, Puerco-Torrejon shale, and in the Wasatch sandstone has not been too successful on the surface because shales show little differential weathering on observable outcrops, and because the Wasatch sandstone is highly cross-bedded and gradational. In many areas covered by Wasatch sandstones, it is believed that surface structures reflect the deeper structures due to rejuvenated folding or draping in early and middle Tertiary time.

Cost of surface mapping in the Basin is about $10 per square mile for reconnaissance, utilizing the plane table and photomosaics. The cost increases to about $20 to $30 per square mile for an experienced two man field party doing detailed plane table mapping. The cost depends upon weather, the number and conditions of outcrops, ruggedness of terrain, and size of the area contractually mapped.

Photo-geologic analysis. This inexpensive method of exploration is in reality surface reconnaissance utilizing aerial photographs. It can be done by one man, familiar with the region, and is feasible over any terrain of the San Juan Basin with varying degrees of accuracy. Results of this work may be represented on maps showing formational contacts, dip and strike symbols, axes of anticlines and synclines, and outlines of areas that should be checked in more detail by rapid field reconnaissance before acreage purchase.

Cost of photogeologic analysis for large areas approximates $6 per square mile, or for simple photo reconnaissance showing only structural axes, $4 per square mile. This is the lowest-cost exploration that can be done, and is successful in many areas where surface work is not possible.

Seismic mapping. Reflecting horizons for seismic analysis include the Greenhorn limestone, the Todilto gypsum, and some as yet undefined horizons in the Hermosa limestone. Seismic work is

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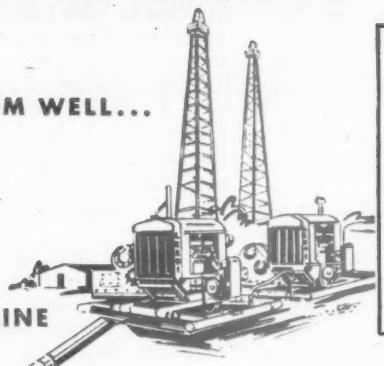

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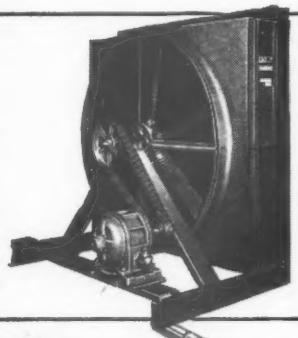

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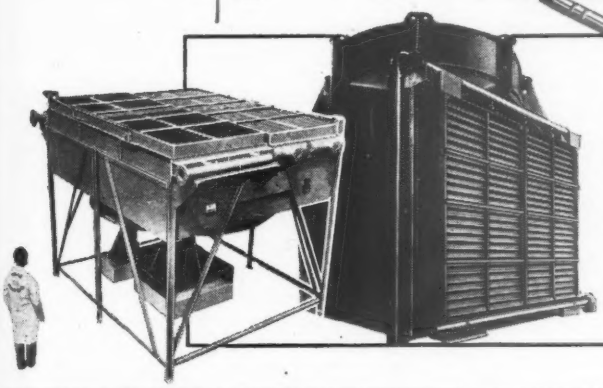

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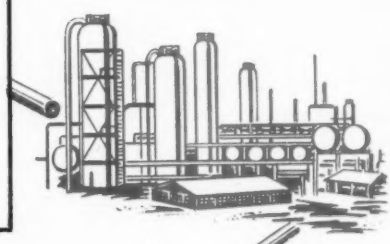

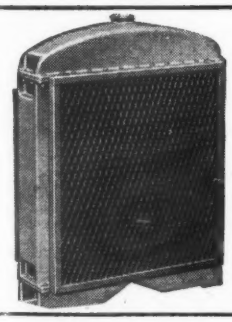

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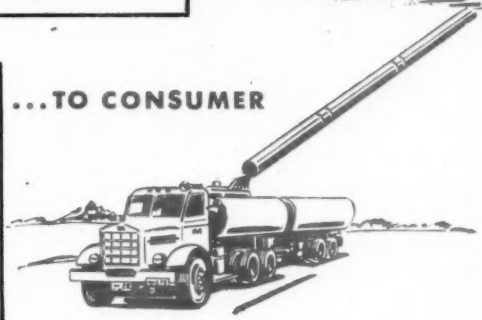

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one of the best methods for exploring unknown subsurface conditions in the San Juan Basin. Not only may valid subsurface structures be determined, but major Cretaceous wedge-edges, and a possible Mississippian wedge-edge, can be mapped by this technique.

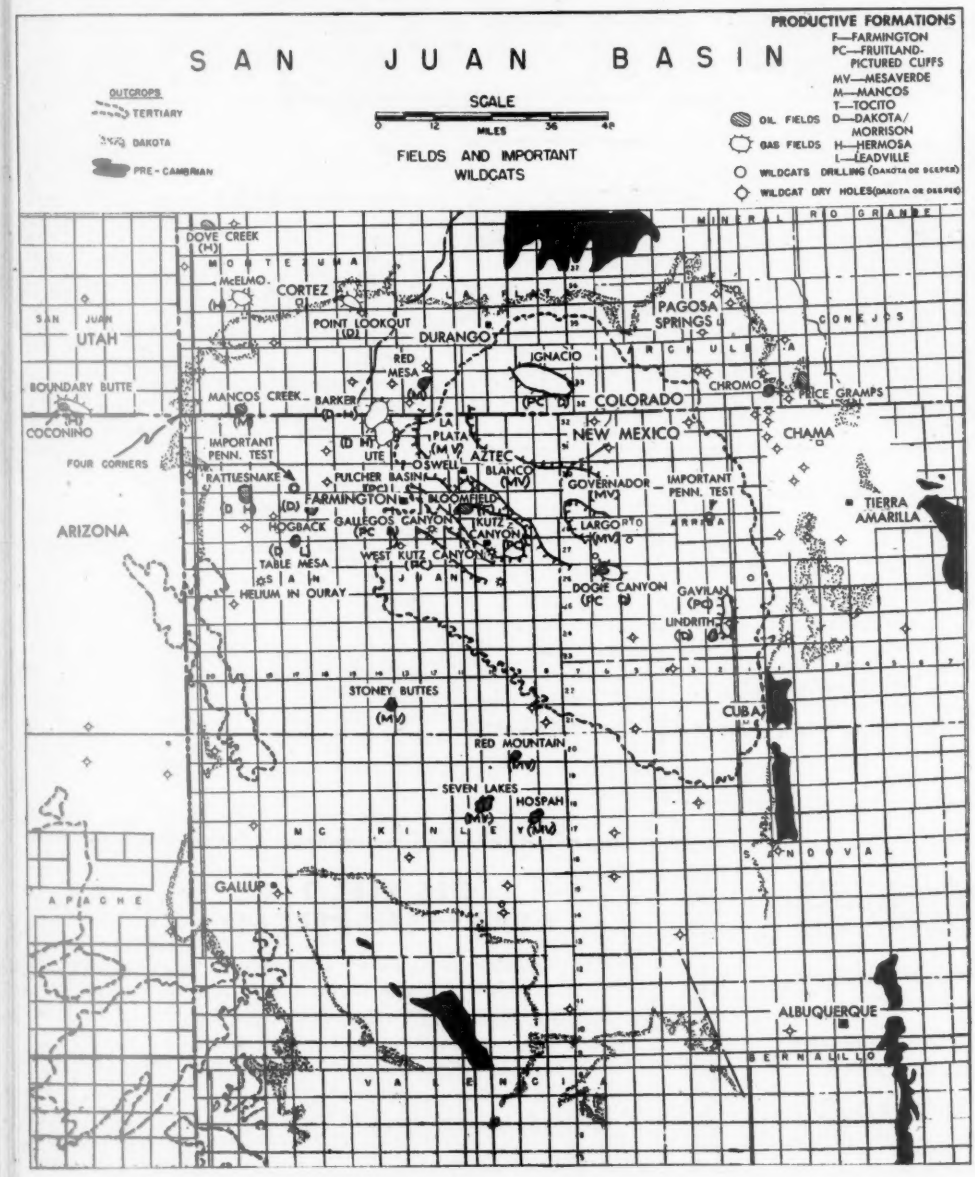
Cost of seismic work, on contract, in the Basin ranges between $15,000 and $30,000 per month. Over flat shale terraines where roads are present, the cost may be as low as $15,000 per month, ranging up to $30,000 per month in the northeast sector where the terrain is rugged and portable equipment must be used. This excellent direct method of exploration is thus our most expensive means, and should only be used for detailed checking of structural anomalies discovered by other means.

Subsurface geology. Insufficient wells have been drilled through the entire section in all parts of the Basin to complete subsurface analyses similar to those possible in the Mid-Continent area, but certain areas of gas development are mappable for further extension and exploratory drilling on subsurface evidence alone. This is particularly true for the stratigraphic trends, in which a major part of logical future exploration with the drill can be guided by careful subsurface work. Contractual cost figures cannot be given on this type of work owing to the number of variables such as the size of area and number of well data available. Experienced consultants, with complete files, now working constantly in the region do subsurface analysis for $50 to $125 per day.

Magnetic surveying. The San Juan Basin is peculiarly amenable to low-cost magnetic analysis. The stratigraphic sections range from 0 to 15,000 ft in thickness, and magnetic work establishes, without too many disturbing variables, the major structural trends that have controlled sedimentation, as well as local trends due to structural and drape folding. The cost of magnetic work covering 10 sections (6400 acres) for one field crew over a period of one month approximates $3000, inasmuch as it is necessary to work at least 50 sections in reconnaissance surrounding the 10 sections, in order to gain regional control for leading critical magnetic anomalies into the block under consideration. Such work also includes geologic interpretation of the magnetic data and tentative locations for exploratory wells. Detailed magnetic work is now being used by some companies to define stratigraphic trends of higher magnetic content in sandstones. The aerial magnetometer has been used to good advantage by several companies in the San Juan Basin.

Gravity mapping. Few cost data are available on gravity mapping in the San Juan Basin, but it is known that the cost is somewhat higher than that for magnetic mapping. Several companies have tried this type of exploration, but the mapped gravity anomalies have seldom coincided with known geologic structures that may or may not contain oil or gas.

FIELDS AND IMPORTANT WILDCATS



Guidance for Further Exploration

Recent developments in exploration by other companies, and the completion of certain critical wells in the San Juan Basin and contiguous areas, suggests that a well-planned exploration program in the southern Rocky Mountain and Colorado Plateau requires a definite program of areal stratigraphic studies for the development of new oil and gas reserves.

The listing of areas for exploration here given is not necessarily in the order of importance, since several of the trends are proved and acreage costs are high. In other areas, the prices are still reasonable and the risks proportionately greater. Areas are described in similar outline sequences for ease of comparison. No effort is made to give details on costs of various methods of exploration or costs of drilling in each specific area. The map entitled "Areas of Future Possibilities" shows those trends the writer considers to have the highest oil and gas potential.

Mesaverde Gas Trend. Northwestern San Juan Basin, Blanco monoclinal gas trend productive from Cliffhouse and Point Lookout sandstone at depths of 4000 to 5500 ft in Blanco field with southeast and northwest extensions proved; initial potentials 3 to 20,000,000 cu ft of sweet wet gas after shot; potential Pictured Cliffs gas sands inadequately tested, initial potentials may be as high as 2,000,000 cu ft of gas per day; Dakota and Pennsylvanian Hermosa potential unknown. Suggest oil possibilities in both of the latter formations at depths of 7000 ft and 10,000 ft respectively, particularly on Governador anticline, western Rio Arriba County.

Methods of Exploration: Subsurface studies, via sample and electric logs now available; construction of isopachous and lithofacies maps. Structural control is relatively unimportant in exploring these gas sands, therefore, careful sedimentational studies are necessary.

Pictured Cliffs Gas Trend. Western

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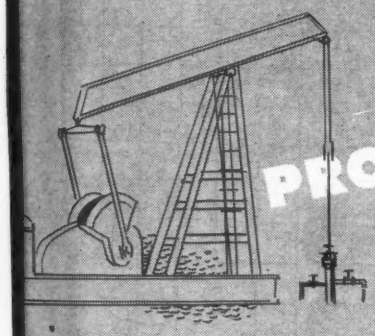

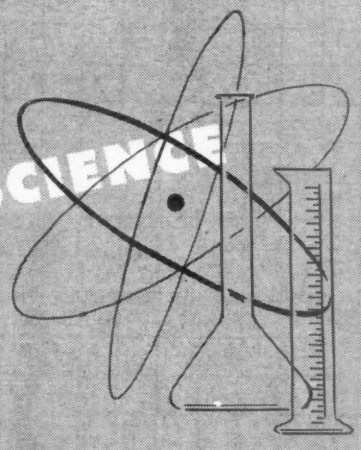

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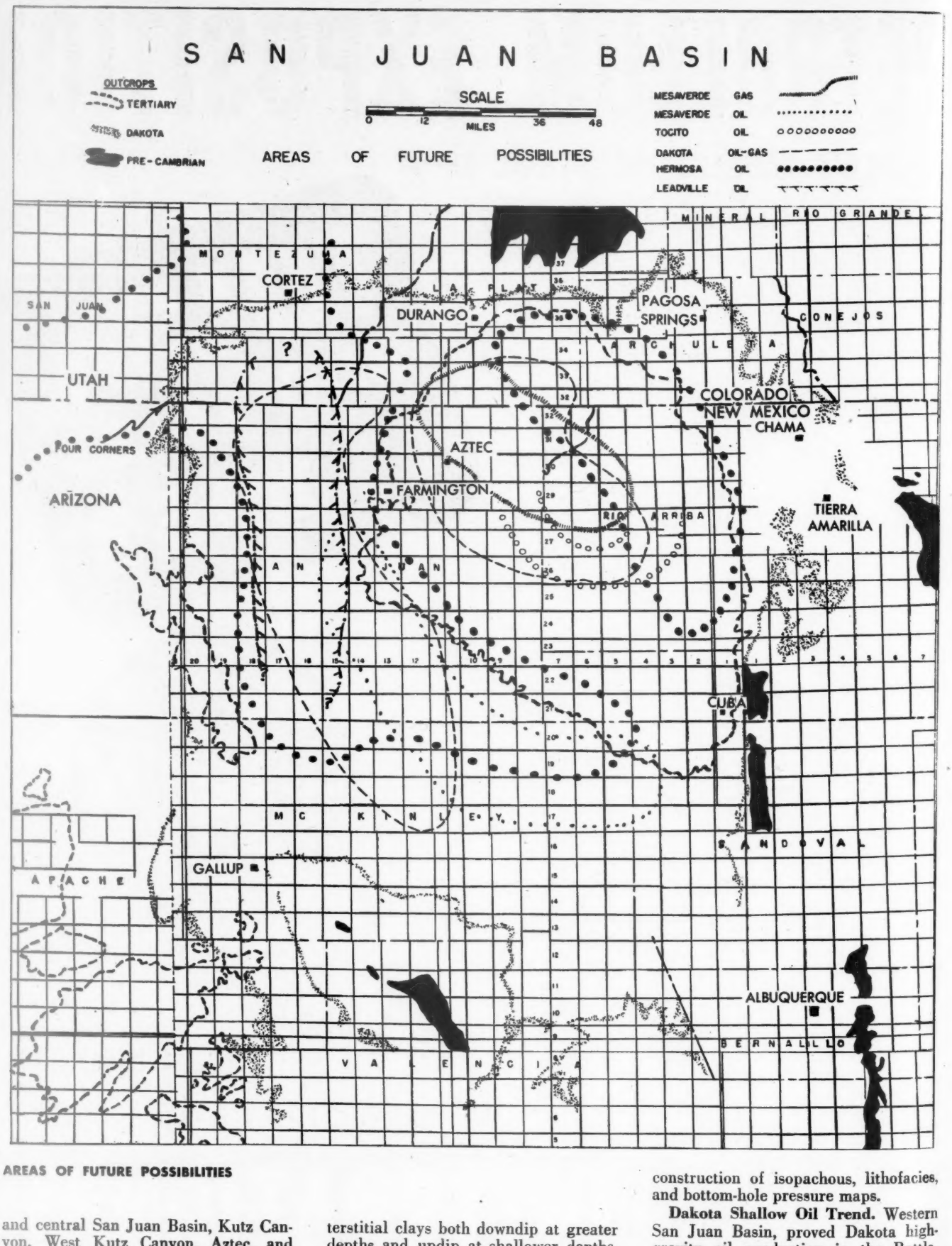

AREAS OF FUTURE POSSIBILITIES

and central San Juan Basin, Kutz Canyon, West Kutz Canyon, Aztec, and Fulcher Basin fields, productive of sweet wet gas from Pictured Cliffs sandstone at depths of 1700 to 2300 ft, with initial potentials ranging from 1 to 6,000,000 cu ft of gas per day. Structure is monoclinal and gas is limited by interstitial clays both downdip at greater depths and updip at shallower depths. Local porosity cross-trends have been proved and local variation of sand thickness plus microfracturing are important.

Methods of exploration. Subsurface studies via samples and electric logs; construction of isopachous, lithofacies, and bottom-hole pressure maps.

Dakota Shallow Oil Trend. Western San Juan Basin, proved Dakota high-gravity oil production in the Rattlesnake, Hogback, and Table Mesa fields at depths of 800 and 1600 ft at the north end of the trend. Field potentials of 100 to 400 bbl per day. Dakota oil recovered with initial potential of 75 bbl of oil and some fresh water in Stoney Buttes

field in the south-central part of the trend. A vast area of untested land totalling about 60 townships underlain by Mancos to Ojo Alamo beds (upper Cretaceous) on the surface. At least four untested anticlines are known in the area. Stratigraphically, the major oil potential is from the Dakota sandstone in which the lower members are known to wedge out southwestward and southward toward the Defiance and Zuni uplifts. Drilling depths of 900 ft on the north to 4200 ft on the east and southeast. Coconino and Hermosa potential unknown excepting in Rattlesnake field.

Methods of exploration. As the oil is found in anticlines, rapid reconnaissance should be made by doing photogeology of the whole area, narrowing the area to detectable anticlinal trends that can be checked by a reconnaissance geologist, and detailed by a surface crew *after* purchase of acreage.

Mesaverde Oil Trend. Southwestern and southern San Juan Basin, encompassing Stoney Butte, Seven Lakes, and Red Mountain fields in the Hosta sandstones, and the Hospah field in the Hospah sandstone. Medium gravity oil with very little gas. Potential Dakota oil and gas at 2200 to 4300 ft where lower Dakota members wedge-out against Morrison irregularities on anticlines; unknown Pennsylvanian potential; Mesaverde oil in anticlines lying athwart certain stratigraphical trends that control mixing zones of fresh water from the southwest and salt water from the northeast.

Methods of exploration. Photogeology and surface checking *after* thorough subsurface analysis of the numerous wells already drilled in the area. Lithofacies and isopachous maps help to delineate trends; photogeology aids in localizing anticlines. Many small anticlines are still untested. Acreage situation is difficult with Santa Fe, Indian allotment, federal, state, and fee lands. Seismic work has been notably unsuccessful and magnetic work appears to reflect large basement anomalies rather than local structure necessary to trap oil in Mesaverde and Dakota beds.

Southwest and West Flank of the Uncompahgre-San Luis Uplift (Colorado and New Mexico). North and east borders of the San Juan Basin. Distillate proved in dolomite of Paradox facies on Dove Creek anticline. Many geologists believe that the interfingering of Paradox marine black shale, dolomite, and granite wash clastics from the Uncompahgre highland will some day yield very large quantities of high gravity oil. Parts of the area have potential oil in wedge-edges of Mississippian beds. Oil will be found in anticlines athwart trends with proper stratigraphic conditions. Depths range from 5000 to 14,000 ft for Pennsylvanian and Mississippian beds throughout this area.

Methods of exploration. Subsurface analysis of widely scattered deep tests, measurement of surface sections, magnetic mapping of Uncompahgre granite spurs, surface checking via photogeology and reconnaissance. This is a highly complex area geologically. Ute and Jicarilla lands, mostly leased, are present at the east end. Pennsylvanian production will someday be found at depths of 5000 to 14,000 ft in this critical trend.

East Shelf-Defiance Uplift, Far Western San Juan Basin. A platform or shelf on the east side of the Defiance uplift during all of Pennsylvanian time, containing porous Hermosa limestone and dolomite, and possibly reefs. The Hermosa section has produced a half million barrels of oil out of two deep wells between 6585 and 6770 ft in Rattlesnake field. Barker Creek field, immediately to the east, has produced tremendous quantities of Hermosa-Paradox gas at 8400 to 9500 ft, possibly from Hermosa reef limestone and Paradox dolomite. This shelf is virtually untested and the writer is certain it exists. Depths of Pennsylvanian tests would range from 5000 to 9000 ft, with production on anticlines athwart porosity trends, whatever their cause.

Methods of exploration. Subsurface analysis, seismic work after photogeologic work to check convergence in shelf beds of Pennsylvanian age. Surface contains several known untested anticlines. Acreage situation is abominable as the entire area lies in the Navajo reservation. (Helium gas has already been proved from every anticline drilled through the Leadville-Ouray limestone; discovery of Leadville oil late in 1950 in the Table Mesa anticline makes this area very attractive).

Central San Juan Basin. Sectors of the San Juan Basin not included in previous descriptions include the northeastern area and the Chama Basin, site of two freak oil fields; Chromo field out of fractured Mancos shale and Greenhorn limestone, and the Gramps (Price) field, a privately-owned development of Dakota oil in a faulted anticline. Late rumors suggest that five of the wells have been deepened to the Morrison sandstone and are now pumping abundant Morrison distillate. In view of the recent 40 to 50,000,000 cu ft of gas per day out of the Morrison sandstone *and* the Dakota sandstone in the Stanolind, Ute B-1, (Ignacio anticline) it has been necessary to consider the Morrison possibilities throughout the northern and central San Juan Basin.

The deepest part of the San Juan Basin lies on the boundary between San Juan and Rio Arribo counties. Little can now be said of the deeper possibilities in the Pennsylvanian section anywhere within the outcrop of Mesaverde sandstones. Depths of 15,000 ft to granite are postulated. Owing to great lateral changes in the Pennsylvanian section along the El Vado-Nacimiento axis, it is not out of reason to believe that a Pennsylvanian oil field will someday be developed along the east side of the Basin along a steep shelf that controlled deposition of Hermosa clastics in the limy Des Moines Sea. Adequate structures near the Nacimiento thrust fault with Pennsylvanian rocks at depths of 5000 to 9000 ft might have accumulated oil, particularly since the section drilled on the high rimming anticlines had some gray shales and clean sandstones mixed with normal limy Hermosa strata. The depth is great, however, and cooperative efforts will probably be needed to complete a 13,000 ft test to granite so near the Nacimiento-Gallina Mountains.

Methods of exploration. Photogeology has proved of some value in working the Tertiary terraines of the San Juan Basin. Magnetic work has outlined regional trends, gravity work is not widely done, and surface work is tricky. Seismic mapping has proved beneficial, but efforts to date indicate that the drill will be necessary to detail adequately the resources of the central, eastern, and south-central San Juan Basin.

Conclusion

The San Juan Basin has a long productive history but a disappointing history of deep exploration (Dakota and deeper). The history of orogeny and epeirogeny in relation to the deposition of porous clastics and the post-depositional production of porosity in carbonates is very complex. The appraisal of surface structure alone is insufficient in delineating new trends of potential oil and gas production. The first prerequisite in deeper exploration is adequate analysis of stratigraphic trends and sedimentational history. Too many surface anticlines have been tried and proved wanting, with many wildcat wells finding both oil and gas production beneath areas with no surface closure. This can only mean that any analysis of this critical area must begin with a careful study of the regional geologic history. Many more deep wildcats will need to be drilled to bring the area to that stage of exploration now enjoyed by West Texas and Wyoming.

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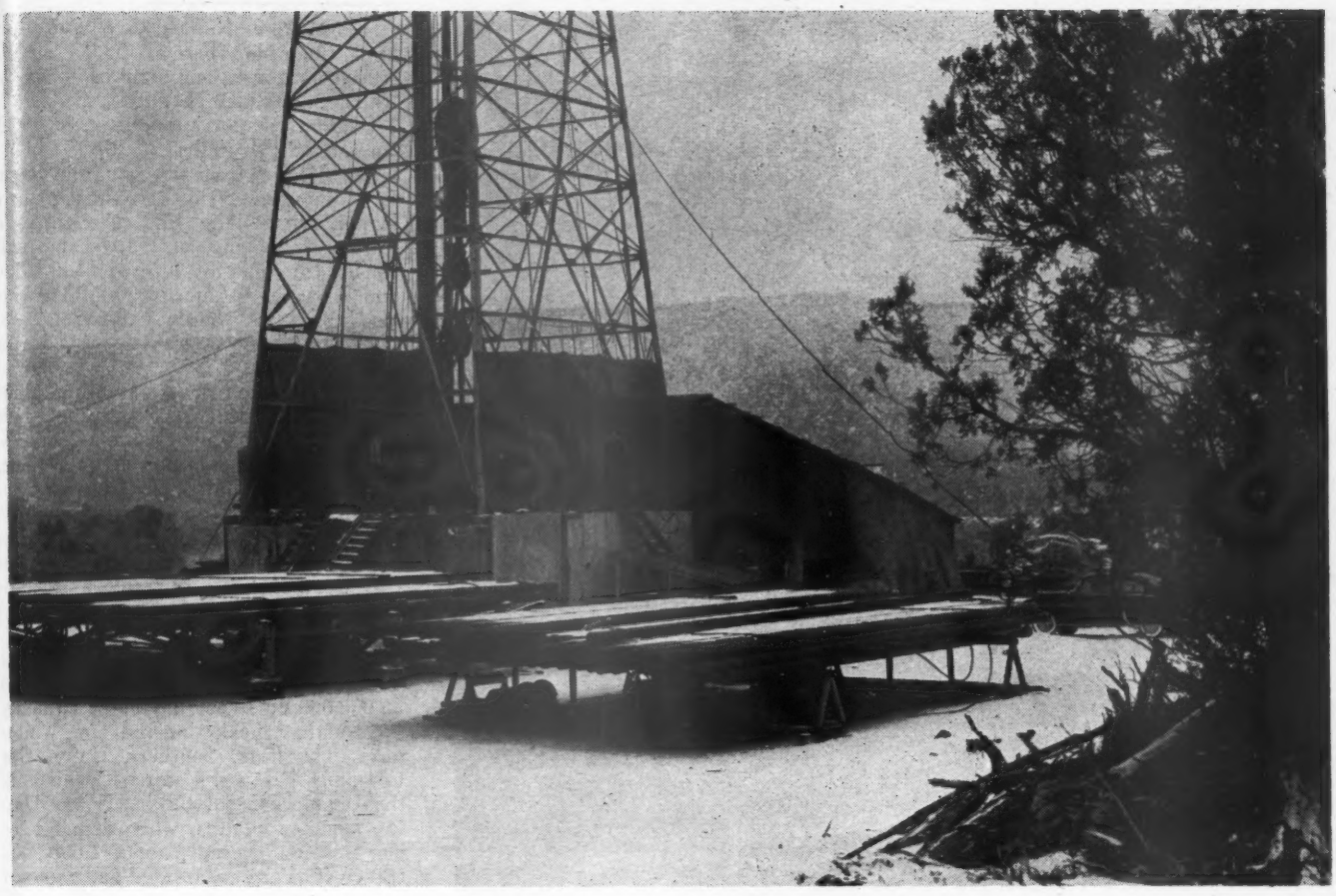

Drilling during heavy snowfall in the San Juan Basin. Lack of paved roads coupled with frigid winter weather makes operations in winter time a difficult and trying proposition in the San Juan Basin.

San Juan Basin Developed on Sound Basis

Better highways, new supply warehouses, more personnel have come from determined efforts to find oil and gas in a desolate area

B. MARSHALL WILLIS

In the old days, when a driller hunting for oil hit natural gas, he was not much happier than if he had tapped salt water. The gas just did not offer much, if any, possibility of return.

Today, when a driller hunting for oil hits natural gas he is usually able to find a profitable market for that gas with the large diameter, long distance transmission pipe lines.

Among the areas of the United States that have benefited decisively from the new market values of natural gas is the San Juan Basin in northwestern New Mexico and southwestern Colorado. Some oil has been produced in that area but it is predominantly a gas producing region. Most of the extensive exploration going on in the San Juan Basin is hopefully directed toward oil but there is no doubt that drillers sleep better at night because of the realization that should gas be found—a probability much stronger than that of finding oil—a market is available for that gas. The driller by selling the gas is able to recover his expenses and to obtain some return for his risks and efforts.

These comments are not intended to disparage the importance of oil to the San Juan Basin. Oil has been discovered there; oil is being produced there; but this oil at the present is more important for its promise than for its volume. Production is considerably greater than a year or two ago and operators are optimistic that one of these days a rich and profitable oil field will be developed.

During 1951 oil was produced from various fields of the San Juan Basin in the following amounts:

Dove Creek	1,800 bbl
Hathaway (Red Mesa)	5,534 bbl
Boundary Butte	3,780 bbl
Hospah	186,390 bbl
Stoney Butte	4,323 bbl
Lindrith	3,570 bbl
Doswell (Lowry)	62,621 bbl
Huerfano	614 bbl
Barker Dome	3,821 bbl
Total	272,453 bbl

EXCLUSIVE

Shooting a gas well in the Blanco Field of the San Juan Basin. This well is El Paso Natural Gas Company's Grambling 2A. There were 2300 quarts of nitroglycerin used to shoot this well.

The promise by this volume of production that there is oil in the San Juan Basin, coupled with the market for natural gas, supported extensive drilling during 1951. Between January, 1951, and March, 1952, more than 400 wells were completed in the basin. In March, 133 wells were being drilled or located.

Much of this exploration is being carried on by larger companies, Delhi, Stanolind, Shell, Continental, Magnolia, and Western Natural Gas Company being among the more active. Two natural gas transmission companies—Southern Union and El Paso Natural—also have extensive drilling programs, but the smaller independents are undertaking a great deal of the drilling and contributing much to the development of the Basin.

It was an independent that developed the most promising recent oil discovery in the Basin, the Doswell Scott Federal 2 (NE NE 9-26-6W) in the South Largo area in Rio Arriba County. This well, which is now operated by Lowery et al of Albuquerque, was brought in in the summer of 1951 and was completed for a flow of 720 bbl a day through choke from the Tocito sand between 6615 and 6692 ft.

In natural gas, great progress has been made in the development of San Juan Basin resources. The proved natural gas reserves of the basin are four times greater today than they were less than two years ago. This improvement is due, in part, to the discovery of gas by drillers hunting for oil and, in part, to exploration purposely directed toward gas.

The market for natural gas is provided by two companies, Southern Union Gas Company and El Paso Natural Gas Company. Southern Union operates intra-state pipe lines in both New Mexico and Colorado; El Paso Natural Gas Company operates an inter-state pipe line through which gas is delivered to northern New Mexico, northern Arizona, and northern California.

Southern Union Gas Company began operations in the San Juan Basin in 1930, taking gas from the Pictured Cliffs formation in Kutz Canyon. In that year, it had 6 wells. Today, Southern Union draws gas from 250 wells in 5 fields—Blanco, Kutz Canyon, Barker Dome, Fulcher Basin, and Ute Dome. In 1951, it delivered 18,200,000,000 cu ft of gas. These deliveries are increasing by more than 10 per cent per year (it is anticipated that 1952 deliveries will exceed 1951 deliveries by 2,500,000,000 cu ft.

Communities served out of the San Juan Basin by Southern Union pipe lines are Albuquerque, Santa Fe, Bernalillo, Aztec, Farmington, Belen, and Los Alamos, all in New Mexico, and Durango, Colorado. There are 55,000 meters served in these communities, 6500 of which were added in 1951.

Southern Union pipe lines, in 1930, consisted of 90 miles of 10-in. and 45 miles of 12-in. from the San Juan Basin to Albuquerque. This was subsequently looped with 12-in. line. Currently, a third loop is being constructed that will consist for some distance of 14-in. pipe and for some distance of 20-in. There is also a pipe line, wholly within Colorado, that serves Durango with gas drawn from Ute Dome.

Southern Union has a treating plant at Barker Dome and a gasoline plant in the middle of Kutz Canyon. Compressor stations are operated at Ute Dome, Kutz Canyon, and West Kutz Canyon and a mainline compressor station is located on transmission lines 60 miles north of Albuquerque. Southern Union Gas Company also operates a government-owned compressor station at Bernalillo.

The treating plant capacity that Southern Union Gas Company enjoys is 35,000,000 cu ft per day. This capacity is less than peak demands on winter days. Therefore, Southern Union Gas Company has a gas storage project in the Dakota zone of Barker Dome. During summer months, when demand for gas is below average, about 1,000,000,000 cu ft of gas are treated and pumped underground. In winter time, this gas is withdrawn at the rate of about 15,000,000 cu ft a day. The gas thus removed from storage added to the gas from the treating plants and from sweet gas wells enables Southern Union Gas Company to meet all demands without, for any appreciable time, having idle treating plant capacity.

In order to meet increasing demands for natural gas, Southern Union Gas

The Author

B. Marshall Willis has been associated with the natural gas industry for nearly seven years, six of them with El Paso Natural Gas Company and one as senior industrial engineer of a company that manufactures instruments and valves. His business background also includes 3½ years in market analysis and market development for United States Rubber Company.

He is an alumnus of Texas Western College and Harvard University's Graduate School of Business Administration.

He is a member of the Independent Natural Gas Association of America, the American Marketing Association, the American Association of Industrial Editors, the Society of Associated Industrial Editors, the American Statistical Association, and other organizations.

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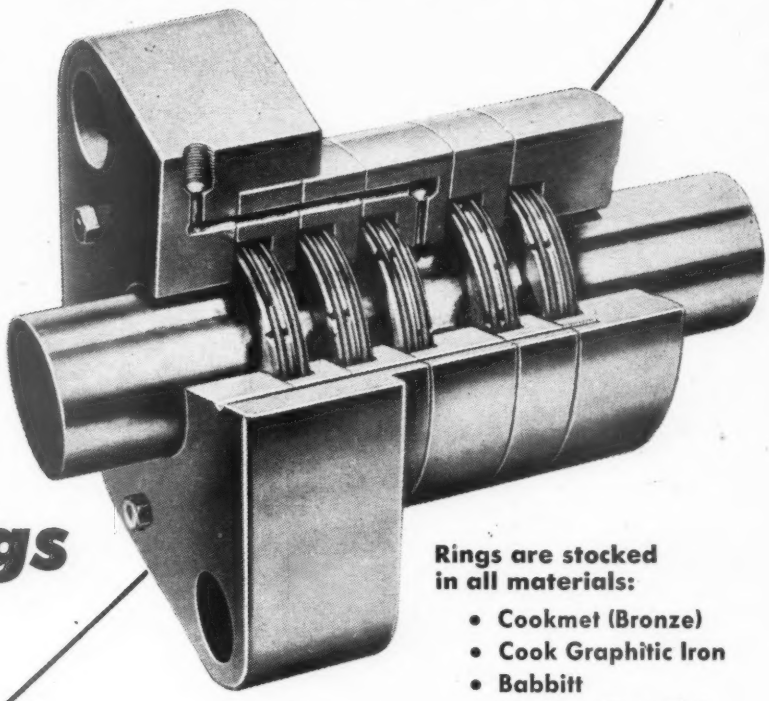

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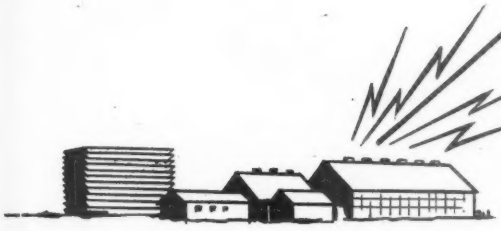

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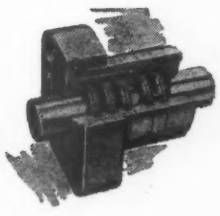


SEALING PRESSURES SINCE 1888

San Juan Basin

Company keeps 6 rigs busy at all times. These rigs complete about 40 wells per year. An additional 40 wells are acquired from independent drillers so that the Southern Union wells are increasing at the rate of 80 or so annually.

In addition to these pipe line facilities and retail distribution systems, Southern Union Gas Company owns and operates the distribution plants in communities along the route of El Paso Natural Gas Company's 24-in. mainline that crosses northern Arizona. Gas service was instituted last spring to Winslow, Holbrook, Flagstaff, Prescott, Kingman, and other Arizona communities. At present, piping is being put down in Gallup, New Mexico, and it is anticipated that deliveries will get under way in that city by early summer.

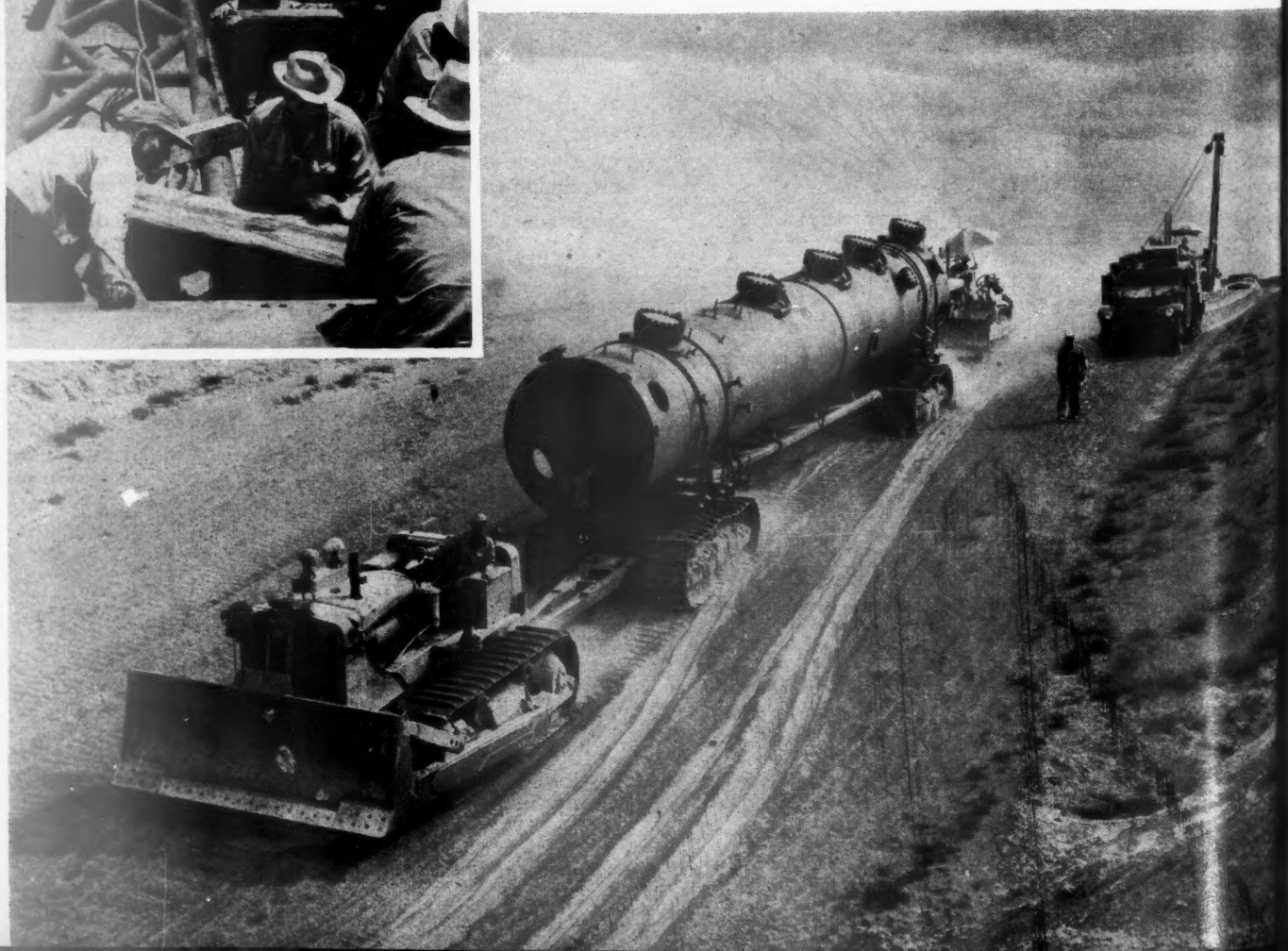
El Paso Natural Gas Company's San Juan Project is operated as an integral part of the company's entire system. The mainline of the San Juan system originates in San Juan County, New Mexico, and extends in a southwestern direction for about 433 miles across northern New Mexico and northern Arizona. At a point near Topock on the Arizona-California border, the San Juan line ties-in with El Paso Natural Gas Company's 30-in. crossover line that carries gas from the southern (Permian Basin) lines of the company.

Under present operations, the San Juan pipe line of El Paso Natural Gas Company is operated primarily as a "fill-in" for gas from the Permian Basin. El Paso Natural Gas Company's Permian Basin facilities are designed and operated primarily to utilize the residue gas that is produced in that area. (Residue gas is a by-product of the production of oil and gasoline. When oil is brought up out of the ground, for example, residue gas bubbles out of that oil just as carbon dioxide bubbles out of soda pop when a bottle of that beverage is opened.)

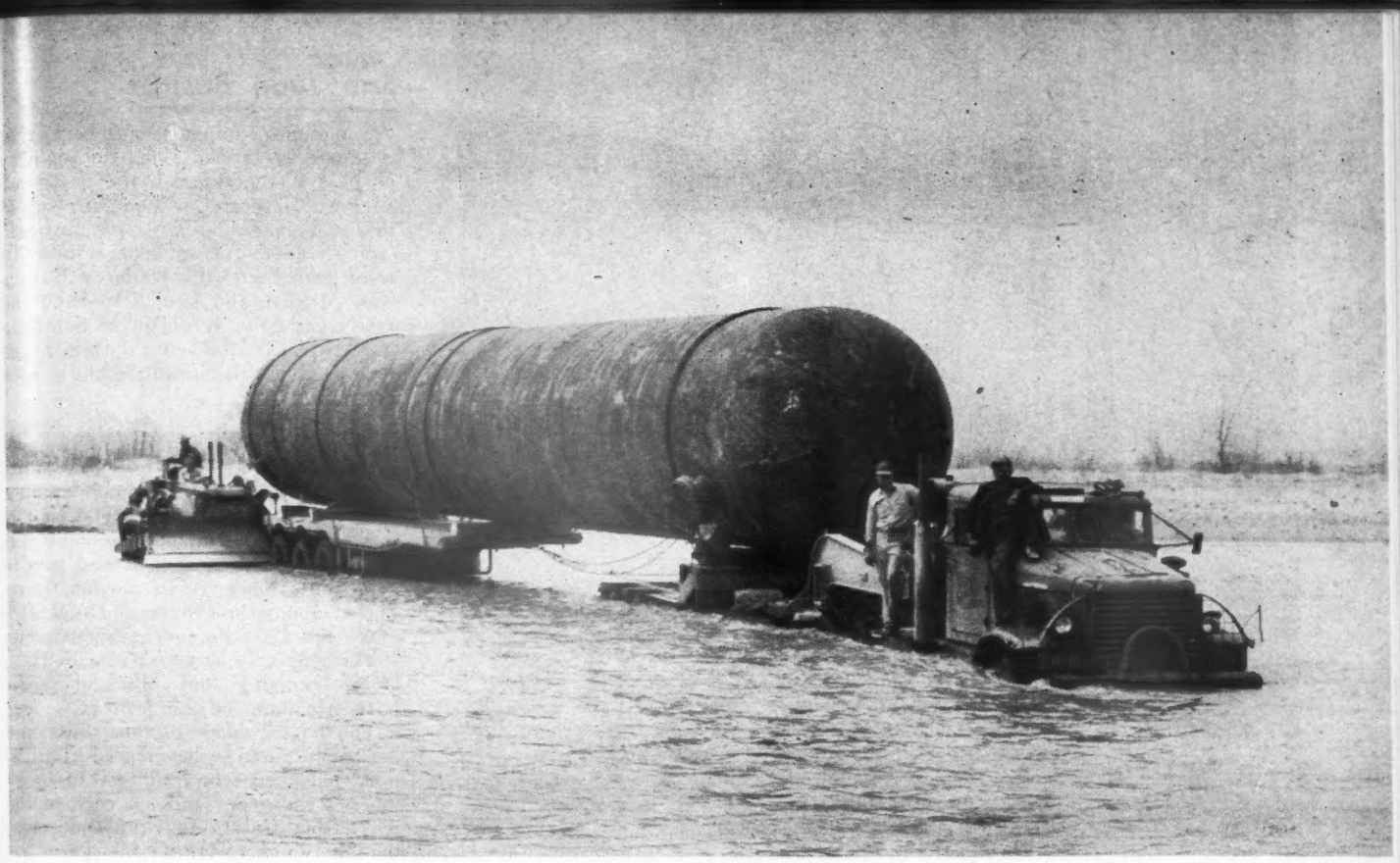
Residue gas is available only when oil is produced and the supplies of residue gas vary, therefore, according to the market demand for oil and not the market demand for gas. From time to time the supplies of residue gas that are available are far short of the volumes of natural gas that are needed by consumers. On these occasions dry gas is used to fill in the gaps. The San Juan pipe line is used by El Paso Natural Gas Company to supply some of the dry gas needed to fill the gaps.

In winter months, for example, the San Juan facilities are operated at full capacity of 167,000,000 cu ft a day but in summer months—or on days in winter when residue gas production in the Permian Basin is high enough to meet market demands for gas—the San Juan pipe lines are practically idle, carrying only 10,000,000 cu ft a day or even less to communities along the pipe line. Of the daily deliveries, 150,000,000 cu ft are to Pacific Gas and Electric Company, which carries that gas from the Arizona-California border to northern California, and 17,000,000 cu ft a day are to Southern Union Gas Company

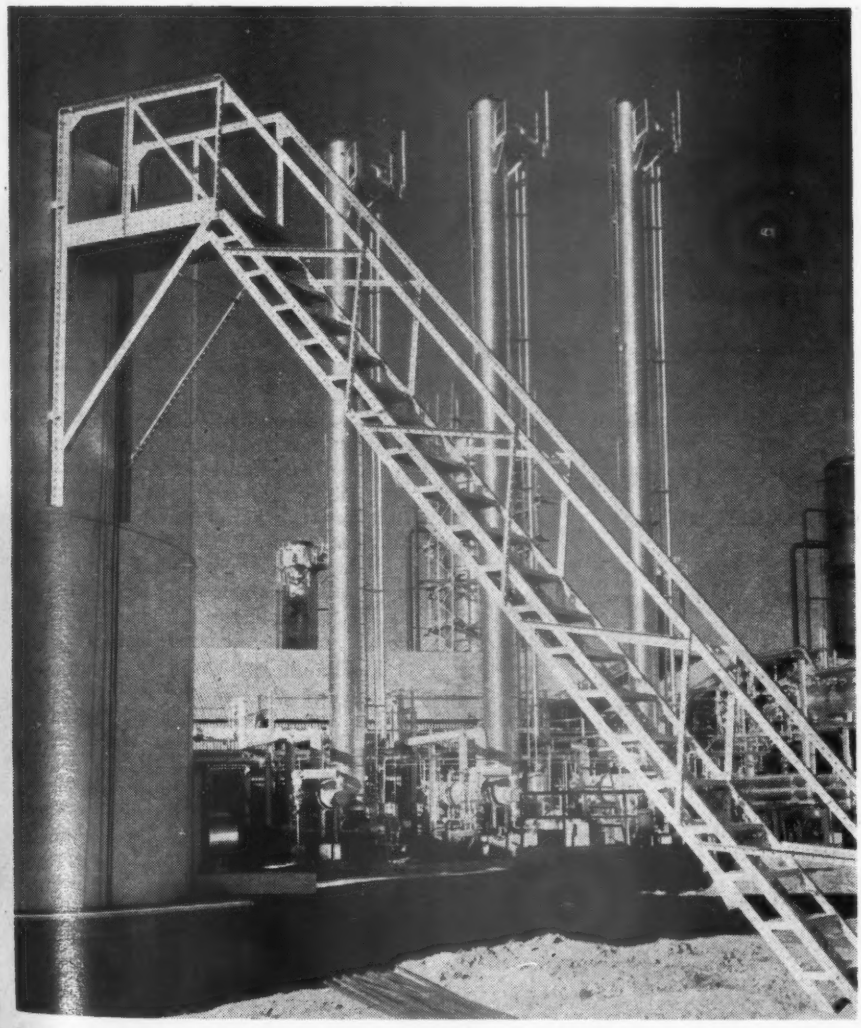
Readying a track-laying trailer for loading with a 185,000 pound natural gas treating vessel. This vessel was so heavy that it could not be hauled along the highway and El Paso Natural Gas Company built this trailer in order to move the equipment along the pipe line right-of-way.



With one cat pulling and two pushing a heavy contactor is moved slowly along the right-of-way of the pipe line of El Paso Natural Gas Company. This equipment was so heavy that it would have crushed the pavement of the highways.



Fording the San Juan River with a large glycol-amine still for the San Juan River Plant.



Natural gasoline absorption towers at the San Juan River Plant of El Paso Natural.

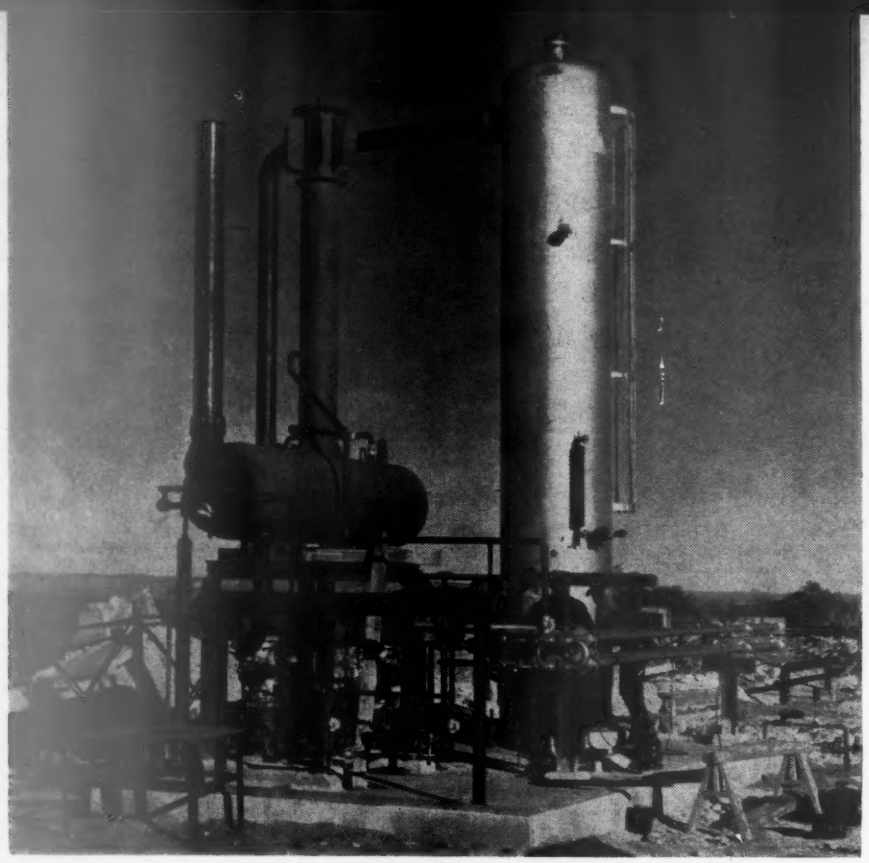
distribution facilities in communities along the route of San Juan mainline.

Because of the great development of proved gas reserves in the San Juan Basin, El Paso Natural Gas Company has applied to the Federal Power Commission for permission to expand operations in the San Juan Basin. These applications ask, first of all, that the company be authorized to operate the present facilities on all days of the year rather than on the fill-in basis as at present and, second, that the daily capacity of the line be increased by 100,000,000 cu ft a day. Thus, the average daily delivery out of the San Juan Basin through the pipe lines of El Paso Natural Gas Company would be increased from the 167,000,000 cu ft as at present to 287,000,000 cu ft a day.

El Paso Natural Gas Company currently has 12 rigs at work in the San Juan Basin. Five of these rigs are owned and operated by the company itself. The company has also acquired vast reserves by purchasing proved acreage from the oil companies.

The facilities of the San Juan system of El Paso Natural Gas Company as they now exist were completed and put into full operation in the late autumn of 1951. Earlier, during the summer months before the treating plant was finished, the company delivered sweet gas from Blanco field through the pipe line to northern Arizona communities.

In the exploration and construction that is being carried on in the San Juan Basin, all companies incur significant handicaps because of the isolation of the region. The only railroad to Farmington is a narrow gage line, which is not big enough to handle the heavy, massive pieces of natural gas treating equipment and oil refining equipment that must be moved to the area. Most of the hauling



Natural gas well at Barker Creek Dome. Horizontal cylinder is a well heater used to keep gas from freezing as pressure is reduced. Vertical cylinder is a dehydrator, which extracts most of the water vapor from gas before it goes into pipe line to be carried to a treating plant.

has to be done by truck. Between Gallup and Farmington, there are 68 bridges that were not strong enough to support the heavy loads of recent construction activity in the basin. These bridges had to be strengthened by shoring-up or by-passed by means of shoo-flies built around the bridges before the companies concerned could haul materials to locations where needed.

Crossing the San Juan River with a heavy load is a problem within itself. There is no bridge along the river that is strong enough to carry the massive oil and natural gas equipment. The custom is to get across the river by fording it. Usually the loaded truck is pushed by a bulldozer while a second truck, on the far side of the river, helps by winching.

San Juan Basin

Sometimes equipment is so heavy that it cannot be carried along the highway because it would crush the pavement. El Paso Natural Gas Company solved this problem by building a large track-laying trailer. The contactors and stills were loaded onto this trailer at Gallup, New Mexico, and hauled to Fruitland (the community at which the San Juan River Plant is built, not far from Farmington) along the primitive, dusty pipe line road.

These trailers were moved for most of the way by three "cats", one pulling and two pushing. For the last few miles, when the terrain became mountainous, four cats were necessary. The contactors weighed up to 185,000 lb and it was a severe test of equipment and men to keep these huge vessels moving. It required about three days and nights to make the 130-mile journey with crews working on a 24 hr per day basis. Half-tracks carrying fuel, oil, and repair parts accompanied the crews.

The bogie wheels of the trailer and the tractors had to be greased every 30 min. The men found white lead to be the best lubricant and, on each of the trips from Gallup to Fruitland, more than 800 lb of it were used.

All in all, the companies now operating in the San Juan Basin are thrown largely on their own resources. They must perform much of their own hauling; they must keep ample supplies of materials in their own warehouses; they must be ready for all emergencies.

Operations within the area are handicapped by the very frigid winter weather that occurs there. During this past winter, snow was very deep for most of the time. When this snow would thaw, the ground turned into thick, clinging mud. The presence of the deep snow and the gummy mud made going tough. Many companies found it impossible to haul rigs and other equipment to location. There is, accordingly, a sudden rush of work underway now that spring weather has arrived.

The gas companies find it impossible in many cases to reach well sites in winter time because of the deep snow. This necessitates the wells being set-up so that they can be operated by remote or automatic controls. At Barker Dome, natural gas is dehydrated as it leaves the well because, otherwise, the gas would freeze in the gathering lines before it reached the treating plants.

The handicaps in the San Juan Basin should become less and less, of course, as the basin resources are better developed. Better highways to the area and paved roads within the basin are being built. The supply companies are setting up warehouses that will carry ample stocks of materials. People are moving to the area to meet the growing need for working personnel. The development that is going on is sound and permanent. The San Juan Basin provides a remarkable example of the benefits to be derived from cooperation among oil and gas companies in the development of an area's resources. * * *

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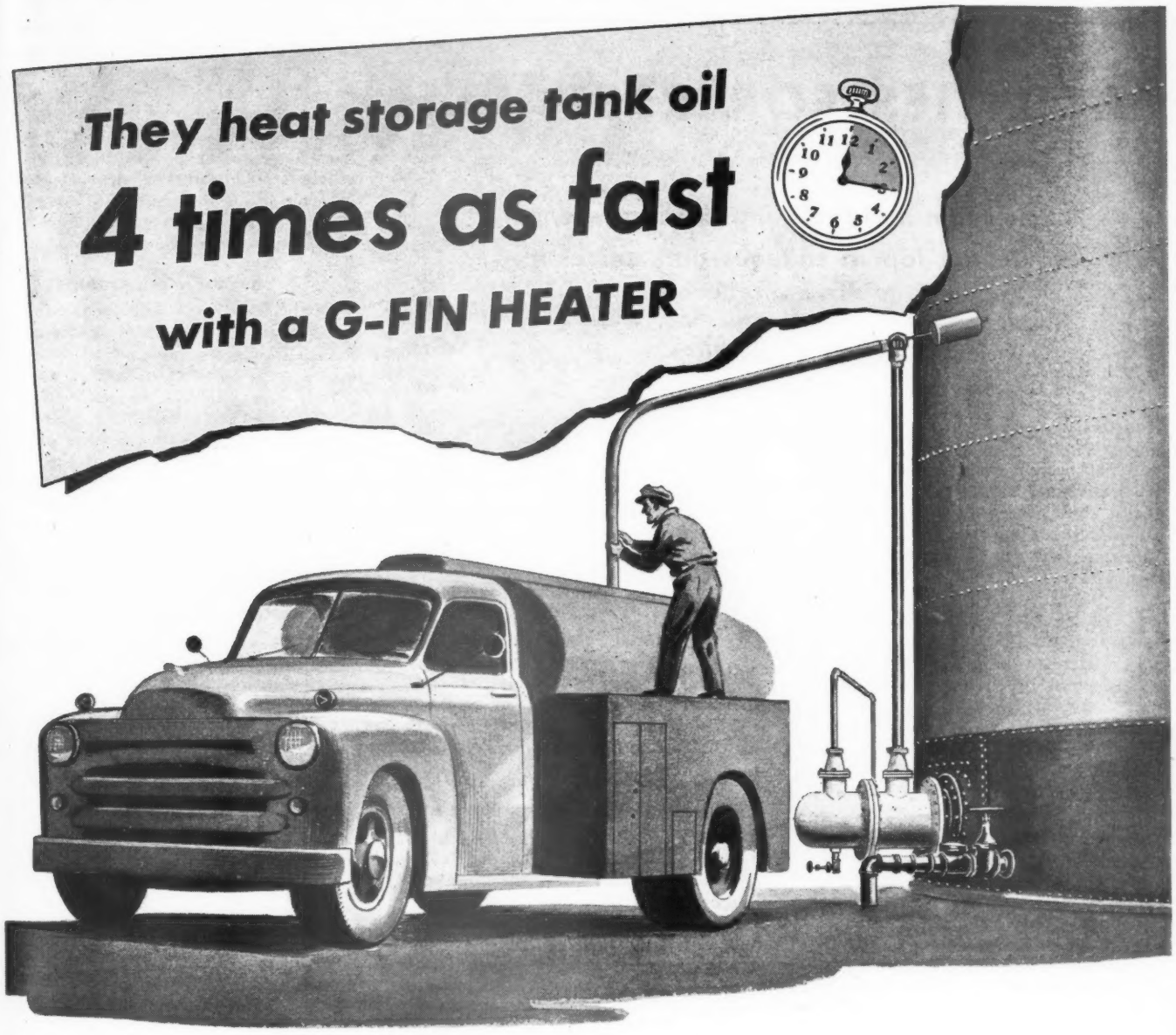

At a petroleum refinery near an east coast community, the oil truck drivers complained about the hour-long turn-around time. They pointed to a nearby refinery where the cold viscous oil in storage tanks was being heated much quicker.

The refinery manager checked, found the other refinery was using G-Fin Storage Tank Oil Heaters, and ordered them for his own tanks. Result . . . the oil was made to flow so much faster that truck turn-around time was cut from 1 hour to 15 minutes.

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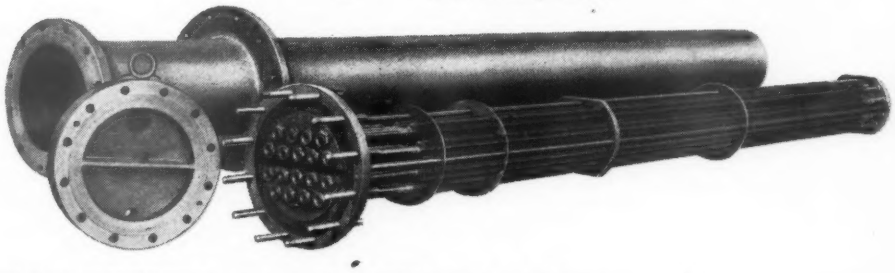

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FACILITIES FOR RESEARCH

Petroleum and fuels engineering research talent on tap in colleges and universities

JOHN I. MATTILL*

THOUGH a comparative newcomer among engineering sciences, petroleum and fuels engineering is a fast-growing field in colleges and universities. Already these teaching programs have generated substantial resources for fundamental research to serve the industry.

In 1951, 65 colleges and universities told the Engineering College Research Council that nearly 200 faculty members qualified to do research in the petroleum and fuels field were available on their staffs. Of these, few more than 100 had research underway. Percentage wise, there is plenty of backlog to meet new calls from the industry.

In the more familiar fields of chemical engineering and geology, too, college and university research talent remains available to be pointed toward the oil industry's needs. There are 150 chemical engineers and 400 geologists competent to do research who have no projects underway; many of these scientists have skills important to the petroleum industry.

These figures come from a national inventory of college and university research resources completed in 1951 by the Engineering College Research Council, a unit of the American Society for Engineering Education. The study was made by the Council's Committee on Relations with Military Research Agencies[1], at the request and with the active cooperation of the Research and Development Board, office of the Secretary of Defense.

The Research Council's survey covered the special interests and activities of faculty and graduate students in all physical and engineering sciences at 750 colleges and universities in the United States. "Substantially all" the national potential for research in these fields at educational institutions is reported, Dean A. F. Spilhaus of the University of Minnesota, ECRC committee chairman, believes.

The results, in summary, show:

1. Nearly 25,000 faculty members in all physical and engineering sciences.
2. Of these, 20,000 are considered qualified to participate in research.
3. At least 12,700 of these are now active in research.
4. An average of 27 per cent of all faculty time is spent on research.
5. At least 45 per cent of this research time is already devoted to defense projects.

Welcome Research Opportunities

The Engineering College Research Council's figures show 209 faculty members and full-time senior research personnel in petroleum and fuels engineering in 65 schools. Of these, 195 are judged qualified to participate in research projects, and 112 of them are now engaged in research. This effort is equivalent to the work of a full-time research staff of 72.7, and of these equivalents 12.5 would be engaged in defense projects for military agencies or their contractors.

In chemical engineering, the figures show 701 qualified faculty members of whom 564 are already engaged in research. There are 1322 qualified faculty members in the "earth sciences" classification—including geology, oceanography, and meteorology—and 964 of them already have projects underway.

Petroleum and fuels engineers number slightly less than 1 per cent of the physical and engineering scientists in colleges and universities; they are doing just over 1 per cent of all research in academic laboratories but only 0.425 per cent of all defense research. Although some of these are involved in fields other than petroleum, most have skills that are appropriate to problems of the oil industry.

Teaching is the first responsibility of all these scientists and engineers. But they and their institutions may be expected to welcome opportunities for fundamental research, which supplements regular academic work.

EXCLUSIVE

The petroleum industry faces little competition from federal defense agencies in using these resources. Defense research accounts for only 17 per cent of the petroleum and fuels projects reported by colleges and universities—the lowest proportion of any of the engineering and physical sciences surveyed. In some fields defense studies are absorbing up to 80 per cent of college and university research time.

Ready for Assignments

Of the 65 schools with faculty qualified for petroleum and fuels research, 40 reported projects underway. In the remaining 25 institutions where no research is in progress, 48 qualified faculty members are ready for part-time assignments. And with only few exceptions, there is also plenty of time for more research in all schools where projects are now underway.

This college research talent has broad interests. Here are the numbers of schools reporting faculty members with experience in these specialized fields of petroleum engineering:

Petroleum and Fuels Engineering:	
Combustion reactions	41
Fuel processing and utilization	29
Gaseous fuels	36
Liquid fuels	50
Lubricants	36
Oil field management	31
Petroleum by-products and derivatives	29
Petroleum production engineering	33
Petroleum refining	32
Petroleum storage and handling	15
Rocket fuels	18
Synthetic fuels and lubricants	22
Earth Sciences:	
Economic geology	175
Geophysics	67
Seismology	39

This obviously does not mean that all schools have equal competence in each field. Potential research sponsors will still have to ponder individual schools' accomplishments and facilities before writing contracts[2].

Teaching, of course, takes precedence over research in educational institutions, and research is considered valuable particularly as it contributes to effective education. Within these limits, the Research Council's figures seem to show plenty of potential in colleges to meet growing research needs of the oil industry.

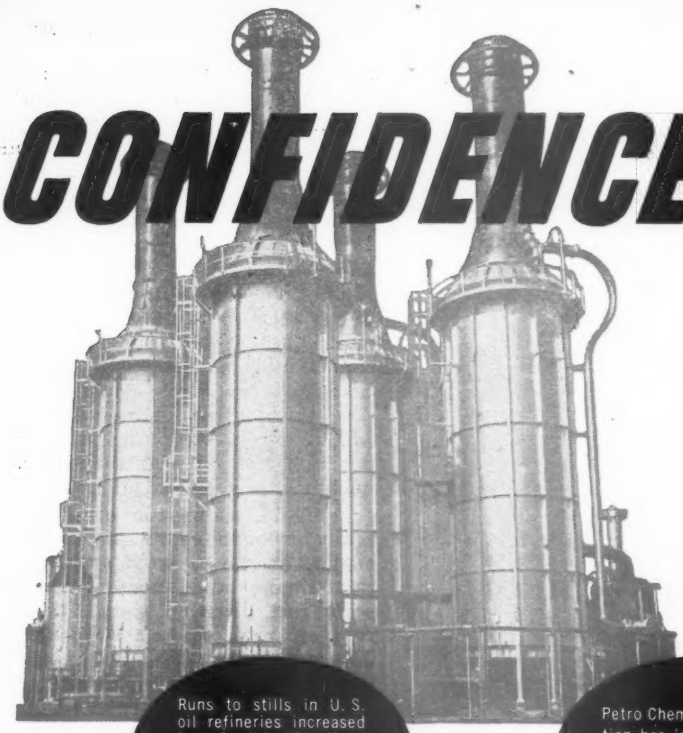
While it benefits teaching, research also helps colleges give wider opportunities and better salaries to competent faculty members. In both ways, increased research undertakings should eventually be reflected in better qualified college graduates for the industry.

*Assistant director, News Service, Massachusetts Institute of Technology; and secretary, Engineering College Research Council — on leave.

[1]Committee members are Dean A. F. Spilhaus, University of Minnesota, chairman; Dr. A. P. Colburn, University of Delaware; Dean W. L. Everitt, University of Illinois; Professor F. B. Farquharson, University of Washington; Professor C. W. Good, University of Michigan; Dr. Paul E. Klopsteg, Northwestern University; Dr. James S. Owens, Ohio State University; Dr. J. R. Van Pelt, Montana School of Mines; and Dean Eric A. Walker, Pennsylvania State College. Dr. Gerald A. Rosselot, Georgia Institute of Technology, is chairman of the Council.

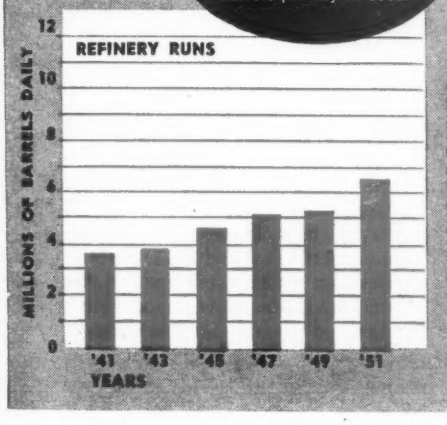
[2]The full report of the survey, entitled "University Research Potential," identifies all schools reporting personnel, competencies, and equipment. Copies are available from the Secretary of the Engineering College Research Council at Room 7-204, 77 Massachusetts Avenue, Cambridge 39, Massachusetts, at $1 each. ★ ★ ★

CONFIDENCE spells growth

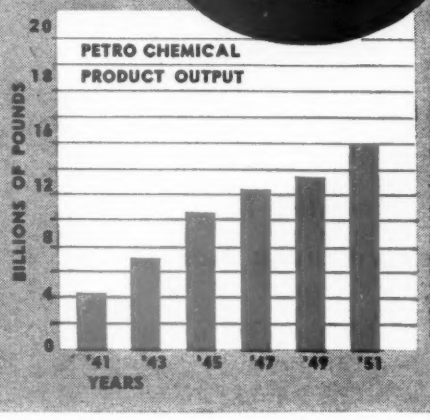


There's many a reason for the parallel growth of the Petro Chemical Industry and the increasing use of Petro-Chem Iso-Flow Furnaces by leading Petro Chemical Companies.

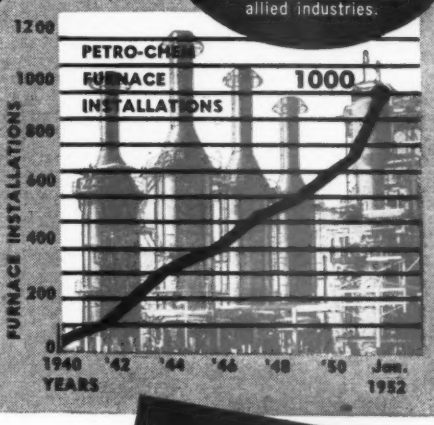
Runs to stills in U. S. oil refineries increased from 3 million 500 thousand barrels per day in 1940 to more than 6 million 500 thousand barrels per day in 1951.



Petro Chemical production has increased from 4 billion pounds in 1940 to more than 16 billion pounds in 1951.



In 1940 there was 1. In 1946 there were 400 and as of Feb 1952 there are more than 1000 Petro-Chem Iso-Flow Furnaces performing in the petroleum, chemical and allied industries.



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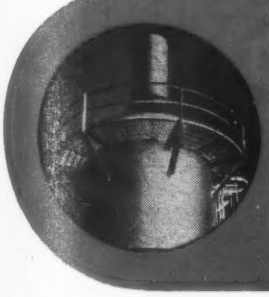

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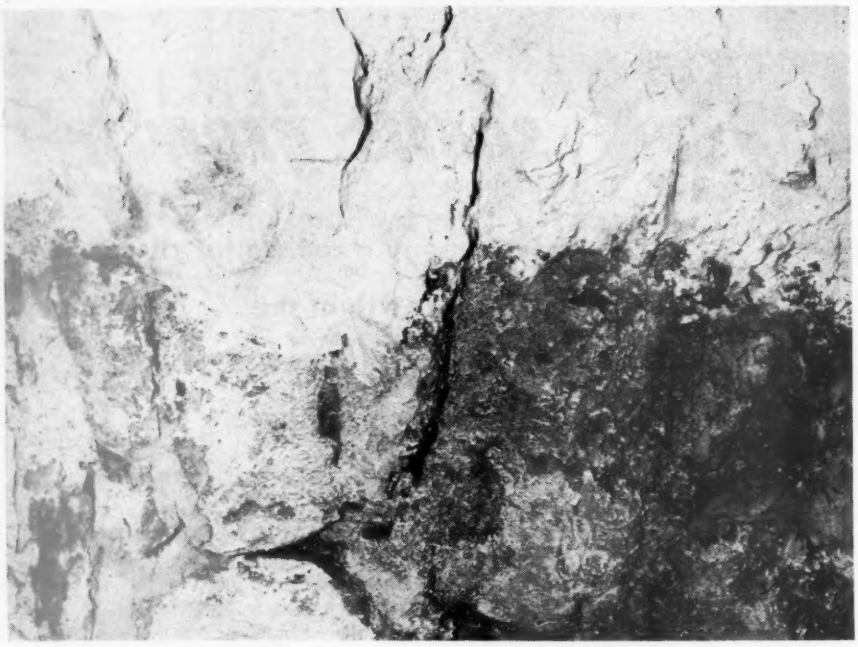


FIG. 1.

Clean Engine Program

Maximum horsepower and long life to a great extent are dependent upon care given machines

J. F. AUSTIN*

We are all prone to consider an internal combustion engine a well perfected machine, and expect it to give its utmost in productive horsepower with a minimum of attention. Actually, if we were to treat the human system with the same degree of negligence accorded many engines, we would soon find old age upon us while still young in years. This axiom holds just as true for an internal combustion engine as it does for the human being.

What we feed an engine (fuel); the attention we pay to its excretory system (exhaust); the attention we pay to its respiratory system (air breathing), and the manner in which we control its temperature (cooling and heating); plus co-ordinated mechanical and electrical functions will in the main determine the productive life of the engine.

As the maximum horsepower output of an engine (diesel or gas), is based on a reasonably well controlled temperature throughout the top and bottom of the engine block, it logically follows that the relationship of the cooling system to the lubrication system should be given the utmost consideration.

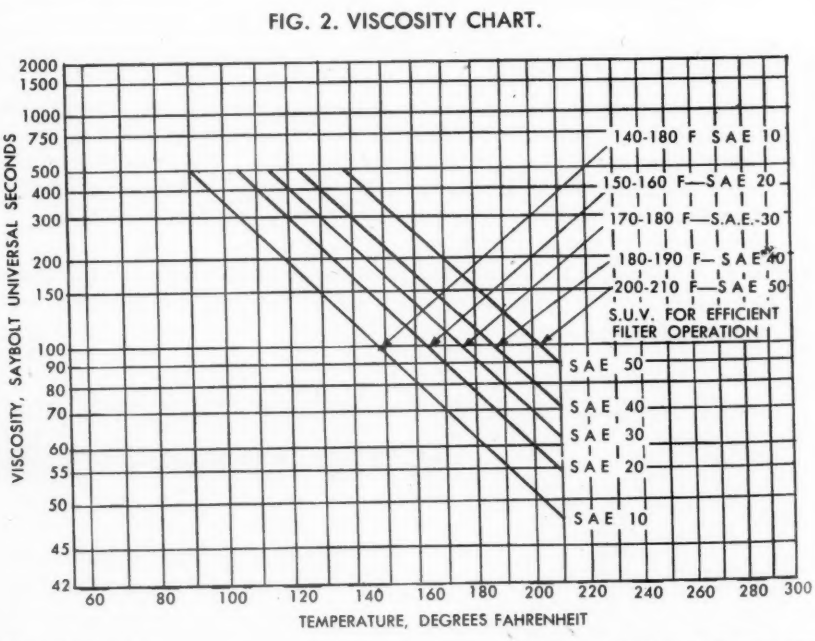
Field operations often times necessitate the use of coolants that quickly cause scale and rust to form in the cooling system. Fairly well defined areas, where the best coolant available is used, show similar tendencies; in fact in some cases to an aggravated degree. The degree of cooling system contamination will always be a constant variable, and hence should be near the top on the maintenance agenda.

Fig. 1 shows the condition generally encountered on the inside of a cooling system of an internal combustion engine when contaminated with scale, rust, dirt, and grease. This photo is blown up several hundred times microscopically, of course. It is not difficult to visualize the impairment to heat transfer through such a mass. Grease and oil, which gets into the system in spite of greaseless pumps, acts as a binder for the contaminants as well as a perfect insulator against heat transfer.

Obviously if heat cannot get through the water jacket into the balance of the engine block, and because of excessive wear engine efficiency will go down. A loss of 5 to 15 per cent in horsepower frequently results. Keep the cooling system clean.

To keep a perfectly clean cooling system water treatment and/or water filtration may be necessary. There are many methods used and your supply dealer can usually steer you in the right direction. If the system does get scaled and rusted up, a caustic solution may be necessary to clean it up. If it is too bad,

FIG. 2. VISCOSITY CHART.



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Viscosity not accurate for any one oil—average of six oils shown.

*Division Manager, DeLuxe Products Corporation.

EXCLUSIVE

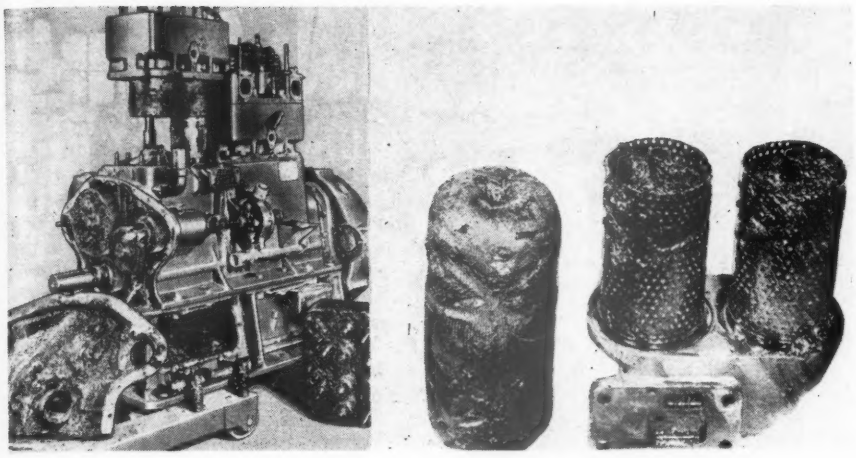


FIG. 3. Result of cold engine. Typical sludge formation both in the engine and in all three filter cartridges. Had the operator recognized the distress signal he could have made proper adjustment of engine temperature and prevented this condition.

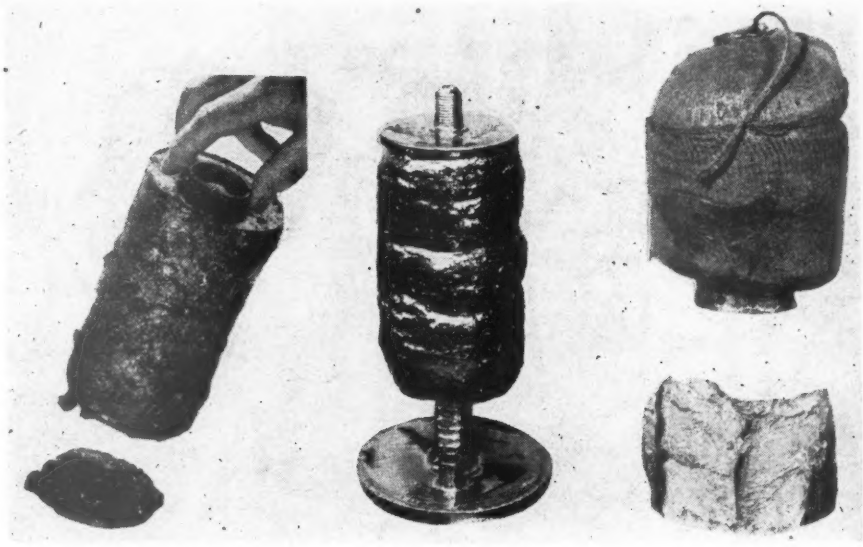
FIG. 4. Typical engine varnish. As the liquid cools it solidifies into sludge, lacquer, gums, etc. Obviously the oil remaining in the engineer crankcase is in a similar condition and when it cools, engine deposits result.

"Roding" may be necessary. Whatever the need, get it clean; then take steps to keep it that way.

The lubrication system relies in part upon heat transfer from the cooling system to maintain the required temperature in the oil in use. Proper oil temperatures are extremely important as a certain lubricating oil will give its peak performance at its recommended operating temperature. Your oil supplier can best tell you what to do with respect to weights and viscosities and temperatures of oil on your particular operation. An oil is asked to perform many functions, namely, lubricate, cool, scavenge, and insulate. To perform these varied functions at peak efficiency it must operate in its own required temperature range.

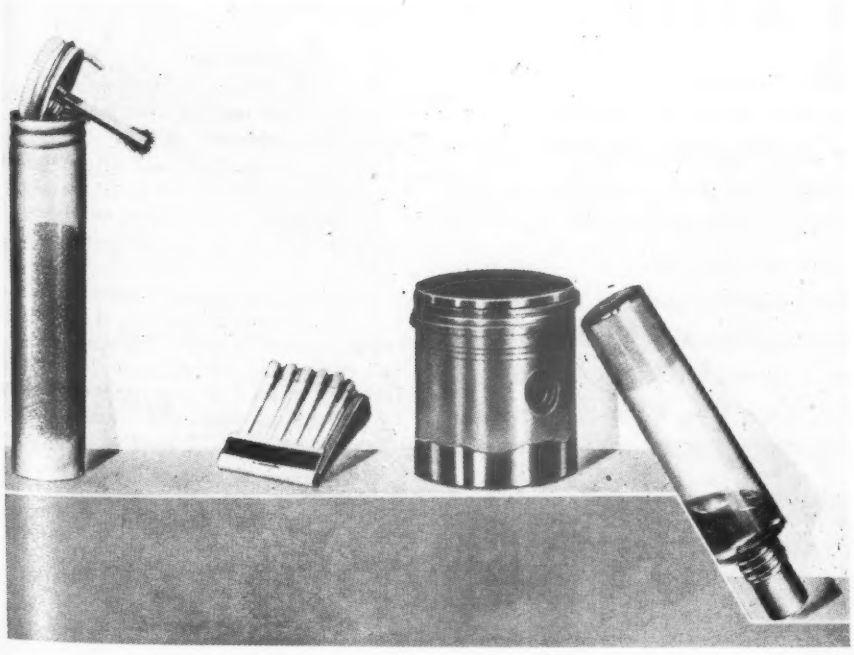
A generally accepted temperature chart is shown in Fig 2. In this chart the middle line indicated by the arrows represents 100 sec Saybolt viscosity, the weights of oil being shown below the middle line and the temperature recommended above the middle line for oils ranging in weight from SAE 10 to SAE 50 inclusive. At 100 seconds of flow in any weight of oil the asphaltenes of oil tend to become heavier and the oil lighter, making possible the absorption of asphaltenes from the oil under adequate and efficient filtration. Asphaltenes along with moisture and dirt tend towards sludge formations under cold operating conditions. Asphaltenes in the presence of excessive heat tend towards varnish formations. In view of these facts, the importance of temperature control becomes obvious.

Fig. 3 shows typical sludge formations both in the engine and on the filter cartridge, collected from a dirty engine. Such sludge conditions may be caused by: 1. Too heavy an oil resulting in low crankcase temperature. 2. Condensate. 3. Water leaks. 4. Excessive blow-by, etc. 5. Lack of thermostatic control. 6. A dirty cooling system. Good maintenance practice can eliminate the occurrence of such conditions. It is quite apparent that an engine contaminated in this manner could not perform effi-



HOT SLUDGE COLD SLUDGE

FIG. 5. Bottle at left contains metal particles, carbon, dirt, rust and sand from engine oil removed by filter. The silicon sand is at the bottom. Good maintenance also makes it advisable periodically to inspect, clean or replace the air cleaner. On the right are shown the gums and resins formed in dilution taken from crankcase oil, which appears quite similar to the varnish or lacquer found in engine. Dilution is caused by incomplete burning of the fuel.



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CASE

Clean Engine Program

ciently, and that excessive engine wear would soon demand an expensive overhauling, or possibly an engine replacement.

Fig. 4 shows a typical engine varnish. A major portion of engine varnishes comes from fuel blow-by rather than from lubricating oil as is often times suspected. This can be true because the fuel being a light hydrocarbon coming in contact with high temperatures in the upper cylinder structure "cracks" quickly into an asphaltene and in turn is baked on to the cylinder and liners in the form of "engine varnish". If these asphaltenes of blow-by are taken to an adequate and efficient oil filter and removed as they form, the possibilities of engine varnish formation are appreciably reduced.

Last but not the least cause of engine wear is abrasive materials entering the engine from the air it breathes. The most efficient air filter that money can buy is the cheapest. Giving it the attention recommended by the maker is good maintenance practice. Fig. 5 shows the amount of abrasive material that accumulates in the crankcase of an automobile engine in 1000 miles of driving The bottle pictured contains silica sand, hard carbon particles, and metal particles. If this happens every thousand miles in an automotive engine, imagine the accumulation that occurs in 50 hours on the average industrial operation! Imagine what occurs in bad dust areas such as the Permian Basin in West Texas!

The bottle pictured contained enough abrasive materials to produce friction strips for 2300 packages of matches. One of the major oil companies made the extraction from the crankcases, had packages of matches made up 2300 from each extraction and used them for advertising the need for strict attention to good lubrication practice, air filtration, and oil cleansing.

It sums up to this. Long engine life and efficient engine performance depend upon good maintenance practice stressing the following factors:

1. **Air cleansing**
2. **Lubricating oil cleansing**
3. **A clean cooling system**
4. **Temperature control**
5. **Established oil and filter change periods based on analysis**
6. **Established air filter servicing**
7. **Established tune up periods**

If the air the engine breathes and the fuel it consumes are clean; if the lubricating system is kept free from sludge and engine varnish and the cooling system is permitted to perform its function by being kept clean, the net result will be an internally clean engine. A "clean engine program" can save you untold dollars in fuel, oil, filter cartridges, engine parts, replacement engines, down time, and loss from inefficiency. Why not start your "clean engine program" today. Specialists in all phases of such a program are ready, willing, and able to help you. ★ ★ ★

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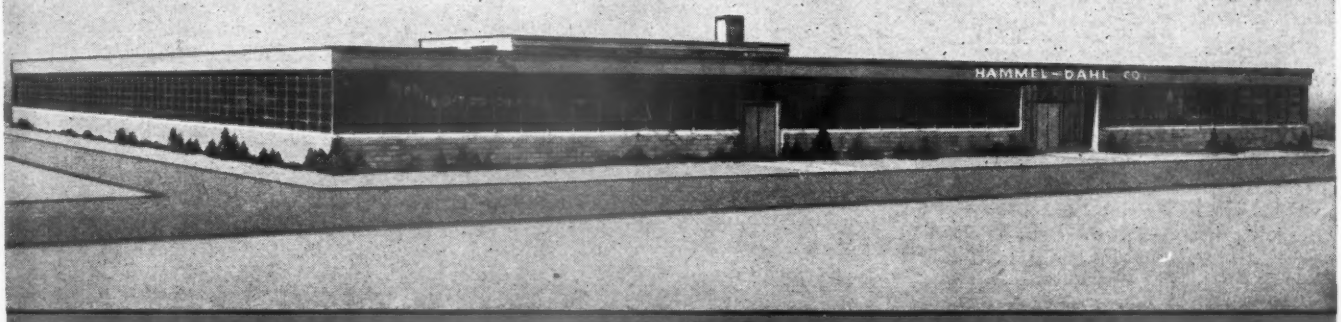

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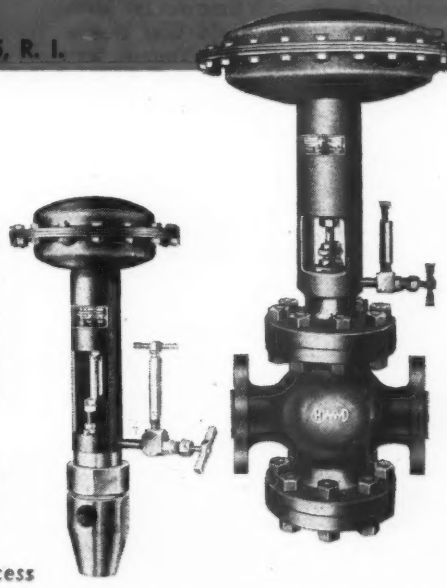

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Petroleum Profile

CHARLES ROLPHI YOUNTS, president of Plantation Pipe Line Company, when commenting upon the completion of the company's $52,000,000 expansion program stated, "This company's greatest asset is its personnel." Employees are impressed with the fact that the office door is always open to them and that "Uncle Charlie"—as he is affectionately called—makes time to listen to their problems. Frequent field trips give those employees away from headquarters that same feeling of belonging. They get the idea that the "Golden Rule" is a practical, sound method of doing business and that the "Rule" works both ways.

This philosophy of Younts' is part of his life off the job too. The 1949-50 Atlanta Rotary Armin Maier award which he received states, "In recognition of his unselfish service to his city—his ideals and performance in good citizenship—and his exemplary fidelity to the principles and objectives of Rotary International." This is a good summation of the man who began as office boy and now heads one of the largest pipe line companies in the world.

Younts' career, until he was selected in 1941 to construct and operate a products pipe line bisecting the southeastern United States, was in the field of petroleum marketing. Beginning as office boy with the Standard Oil Company (New Jersey) in 1912 at Charlotte, North Carolina, he moved through a succession of marketing jobs with time out for Military Service during World War I as a First Sergeant. In 1934 Younts was transferred out of the southern marketing areas to head up the Rochester, New York Division of the Colonial Beacon Oil Company, a Jersey subsidiary. From there he went to New York City on the consolidation of Beacon's Rochester and New York Divisions in 1936, and, in the same year, to assistant division manager, Esso Standard Oil Company's New Jersey Division.

In 1939 the Jersey Company had under consideration the building of a products pipe line to supply marketing areas in the southeast with products manufactured at its Baton Rouge Refinery. Younts, because of his wide knowledge of the South, was called in for consultation. On July 16, 1940, he was appointed president of the newly formed company, which is jointly owned by Standard Oil Company (New Jersey), Shell Oil Company, and Standard Oil Company (Kentucky).

The idea of piping oil across country from the Gulf to the Atlantic Seaboard received strong opposition from influential factions. Tanker sinkings and proximity of war caused the project to be considered essential. Construction of the main line began in August, 1941, and product pumping began January 1, 1942. During this phase, the embryo company had to recruit and train personnel, obtain rights-of-way, materials and supplies, and get underway when all kinds of commodities were scarce.

Charles Rolphi Younts

President

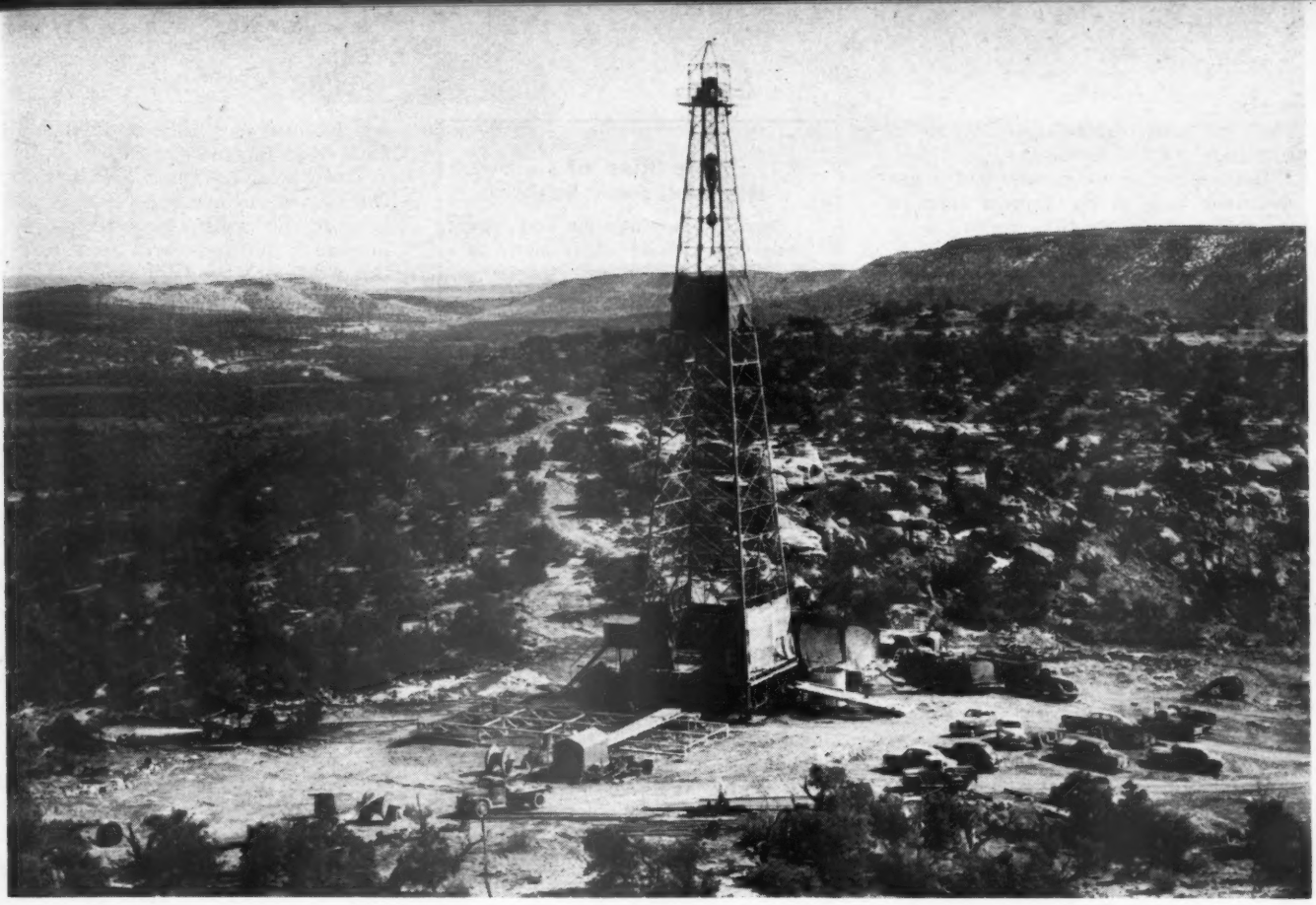
Plantation Pipe Line Company

The accomplishment of building and operating a pipe line during the war was outstanding. Another chore was in the picture — the selling job on the South's future. Few people envisaged the tremendous postwar industrial and agricultural development that was to take place. Younts was one of these. He campaigned for money to establish and expand southern research centers. He held his company's equipment on a standby basis after the postwar drop in petroleum consumption, anticipating a return to even greater product throughput. And—to be remembered by his employees—he made places for them and continued to run a profitable business.

Vision and hard work pays off. In July, 1950, the directors authorized the expenditure of $52,000,000 to expand the pipe line system from its original design of 60,000 bbl a day to an estimated requirement in 1952 of 200,000 bbl a day. The major portion of this project is complete. It comprises a parallel line between Baton Rouge and Charlotte with necessary pump stations and tankage. The picture of progress still moves forward. In April, 1952, another authorization for the expansion of lateral lines was made. By the end of 1952, 221,000 bbl a day capacity will be available.

Who's Who lists the many fraternal, civic, and social organizations with which Younts is affiliated. Their variety gives a cross-section of a man who states, "I won't join an organization just to be joining, it has to serve a worthwhile purpose and be going in a direction that will warrant my time and energy."

Younts is proud that he heads a company that has expanded with the South, that it is a company that endeavors to develop good and progressive citizens, and that it is the employees who have created so much of its success. He has a right to say, "Plantation's biggest asset is its employees."



Barker Dome field. Wells are drilled through the Paradox limestone to a depth of over 9000 ft. Perforated casing and acidizing is the usual completion method. The produced gas has a 1 per cent H_2S and 15 per cent CO_2 content. This field also has production from the Dakota sand, top of pay 3000 ft.

P 420.

What Stirs in the San Juan Basin?

Proved gas reserves are 4½ trillion cubic feet with limits still undefined

JACK MENNEER*

ALMOST 75 years ago oil seeps were found along the San Juan River near Mexican Hat. In 1911 while drilling a water well at a depth of 300-400 ft in the Mesaverde formation in the Seven Lakes area of McKinney County, New Mexico, Henry F. Brock discovered the presence of gas and also 30 deg gravity oil. In the '20s shallow oil drilling was carried out by the Gypsy Company, Continental and others.

Activity centered around the San Juan Basin in 1930, when attention was brought to the area by the completion of Southern Union Gas Company's gas pipe line from Kutz Canyon field to the towns of Albuquerque and Santa Fe.

The reasons for the slow development were twofold. First, the territory is situated far from the old lines of communciation, and access to the basin for transporting oil field equipment presented a formidable task. Second, and coupled directly to the first, was the fact that the productive formations of the San Juan Basin were extremely tight under past production methods.

Today, with new techniques and modern equipment the one time dormant San Juan Basin is now active, and the search for oil and gas proceeds unabated. It is indeed, an area of great promise.

The promise is being fulfilled. In 1950 only 85 gas wells were drilled in the basin by the industry and in 1951 over 200 wells came in as gas producers. During 1952 the Southern Union Gas Company alone proposes to drill 50 new wells. At the beginning of this year there were about 100 operators actively engaged in drilling in the San Juan Basin.

This 100 miles square basin, elevation 5000 to 7500 ft, is located in northwest New Mexico and extends into Colorado. It lies in the "Four Corners" region and is near the boundary intersection of four states namely, New Mexico, Colorado, Utah, and Arizona. Geographically, to the north in Colorado is the San Juan mountain range, to the south in New Mexico the Zuni Mountains, to the east in New Mexico are the Nacimiento Mountains and to the west in Arizona is the Defiance Uplift.

Limits Unknown

The oil and gas limits of the San Juan Basin have by no means been determined as yet. The proved gas reserves are approximately 4½ trillion cubic feet.

Southern Union Gas Company was an early pioneer in the San Juan Basin, and moved in there way back in 1929. By 1930 they had completed the Kutz Canyon-Albuquerque-Santa Fe gas pipe

*Editor, Drilling and Producing.

EXCLUSIVE

line, which was extended in 1932 to incorporate the Ute Dome field.

During 1942 the company had a gas discovery well in the Dakota sand in the Barker Field. In 1945 the first deep well was drilled to a depth of 9466 ft, and resulted in the discovery of commercial gas from the Paradox sand. The produced gas from this formation has a 1 per cent H_2S and 15 per cent CO_2 content, and consequently in 1946 a treating plant was installed.

The Boom Commences

The spark that touched off the great boom in the San Juan Basin occurred in February, 1949, when Southern Union and the Delhi Oil Corporation discovered and produced the Mesa Verde sand in their jointly owned Riddle well in the Blanco field. The mythical pendulum of the San Juan Basin then swung from an area of doubtful possibilities to that of great potentialities.

This Riddle well was drilled by rotary to the top of the Cliff House where 7-in. casing was set. Cable tool drilling was then used to penetrate the Cliff House, Menafee, and Point Lookout sections. On completion the well had a natural potential of 560,000 cu ft per day and by applying 750 quarts of nitroglycerine the natural potential was increased to 9,000,000 cu ft per day.

In September, 1949, Southern Union drilled the discovery well in the La Plata field, in the Pictured Cliffs sand. By 1951 it was found that this formation was continuous throughout the La Plata and Blanco field, and the area is now classified as the Blanco-La Plata field.

The Rise of the San Juan Basin

Several years ago the San Juan Basin was considered by many as an unprofitable venture.

Southern Union Gas Company, old pioneer in the area, has shown that although the gas formations were originally difficult to produce, they can be made to produce successfully if the correct technique is employed.

Van Thompson, manager of exploration, Southern Union Gas Company, is confident that there is a great future for this "area of promise."

Southern Union operations are in four fields in the San Juan Basin: Kutz-Fulcher, West Kutz, Blanco-La Plata, and Barker Dome.

The Kutz-Fulcher field covers 45,000 proved surface acres and is undefined to the southeast. The productive formation is the Pictured Cliffs sand with an average thickness of 36 ft and top of pay at 1700 to 2000 ft.

The West Kutz field is parallel to the Kutz-Fulcher and a permeability barrier separates them. The proved surface acres are 54,000 and the field is undefined to the northwest and southeast. The pay zone is the Pictured Cliffs sand, which is between 1400 to 1600 ft with an average thickness of 28 ft.

The Blanco-La Plata field has 320,000 proved surface acres and is undefined to the north and southeast. Two producing horizons are prominent in this field, (a) the Cliff House sand at approximately 4000 ft, which has an average thickness of 37 ft; (b) the Point Lookout sand at 4600 ft, with an average thickness of 36 ft.

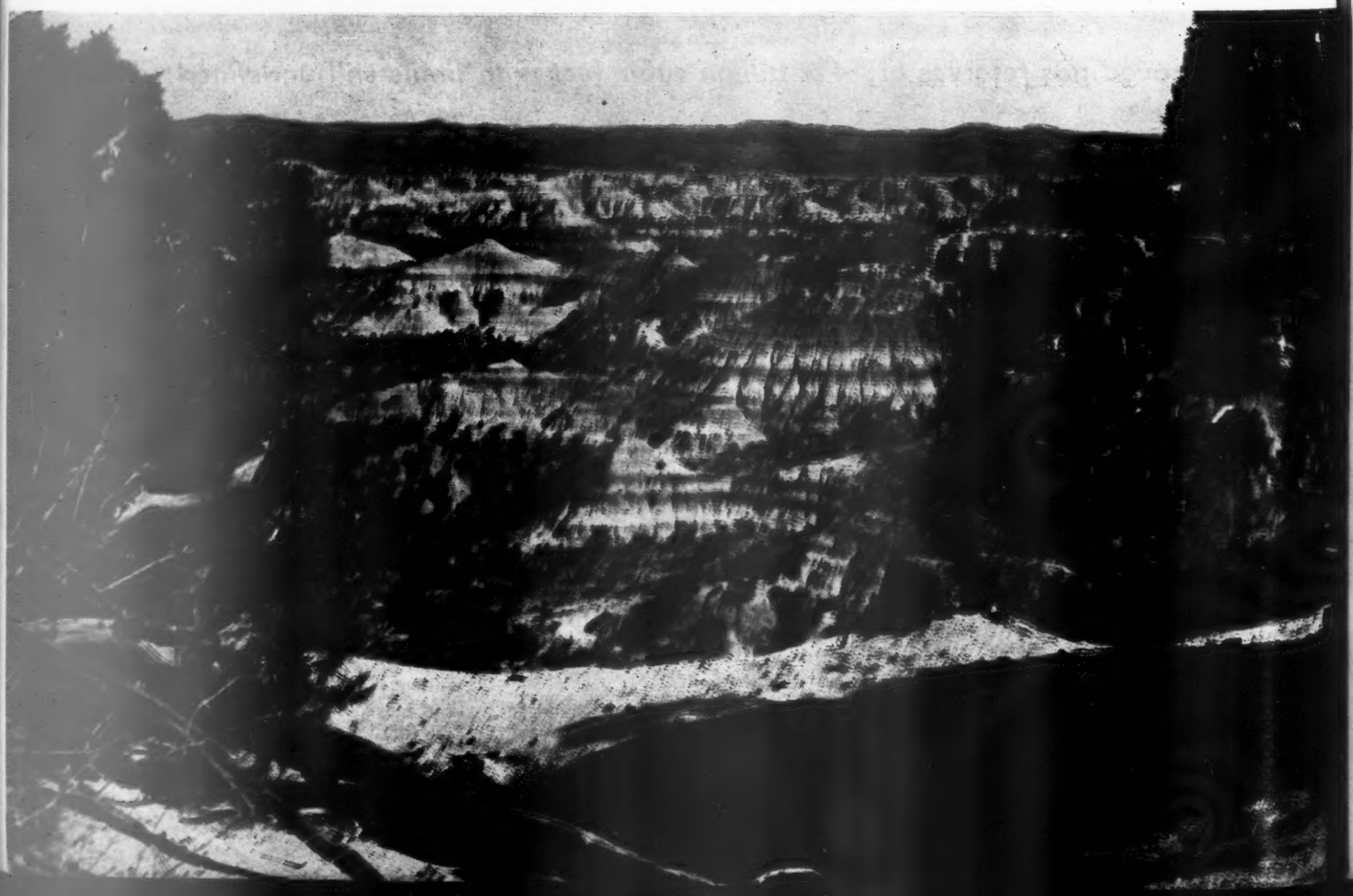
The Barker Dome field also has two pays. The upper is the lenticular Dakota sand with a proved surface acreage of 11,000. The top of this formation is at 3000 ft and has an average thickness of 50 ft. Southern Union is using a partially depleted portion of this sand as a storage reservoir for any excess pipe line requirements or, on the other hand, as a readily available source to boost the gas line demand if necessary.

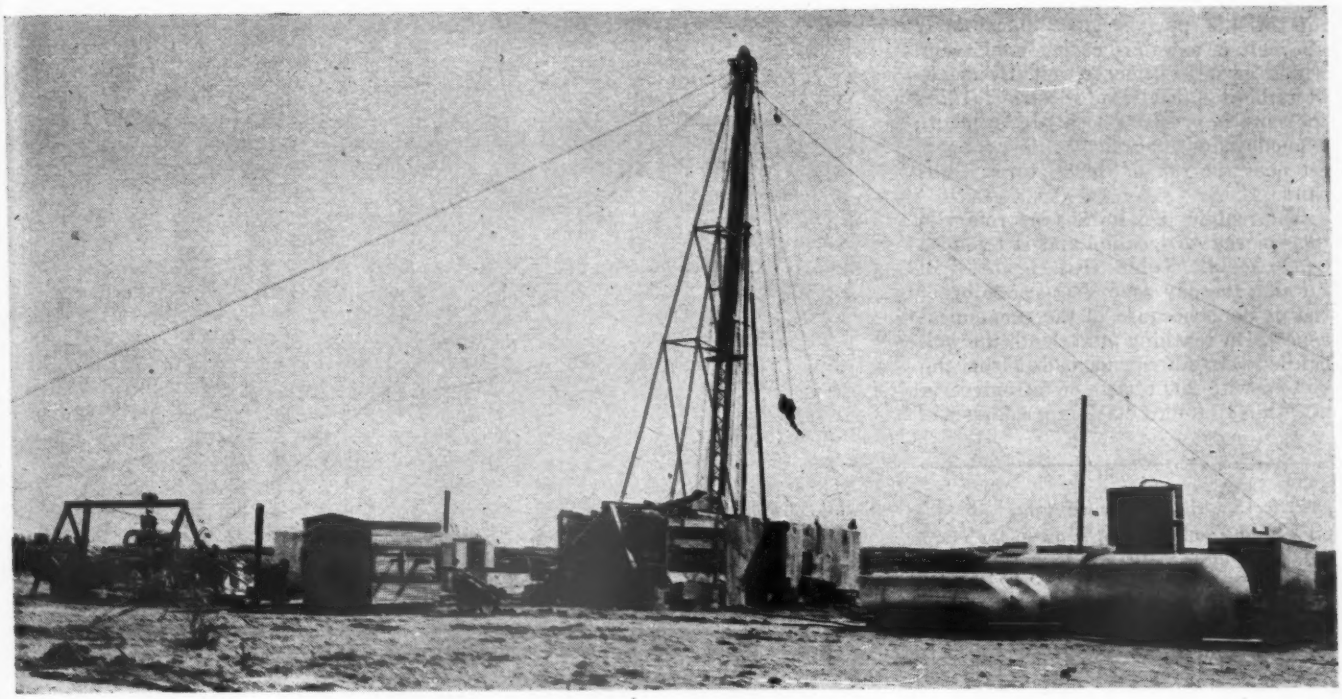
The lower pay at 9000 ft is the Paradox limestone, which has approximately 17,000 proved surface acres. This formation consists of three stringers with a total average thickness of 103 ft. Three methods are employed by Southern Union to bring the various formations into production.

Rotary Rig, Cable Tool Rig and Explosive Charge

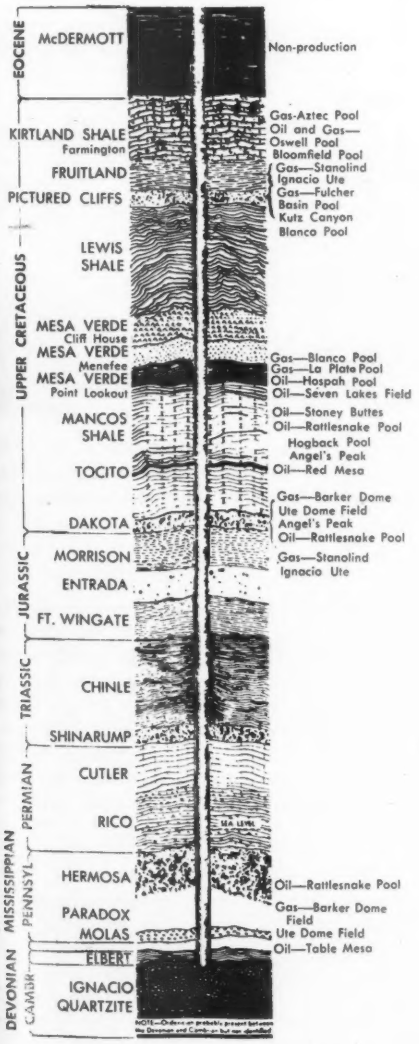
In the Kutz-Fulcher and West Kutz fields surface casing is set at 150 ft and the hole is drilled with a rotary rig and a normal clay base mud to the top of the pay, 1400 to 2000 ft, which is the Pictured Cliffs sand. It is extremely important to know the exact depth of the

San Juan Basin country. Canyon in La Plata field. Type of terrain pipe lines transverse.



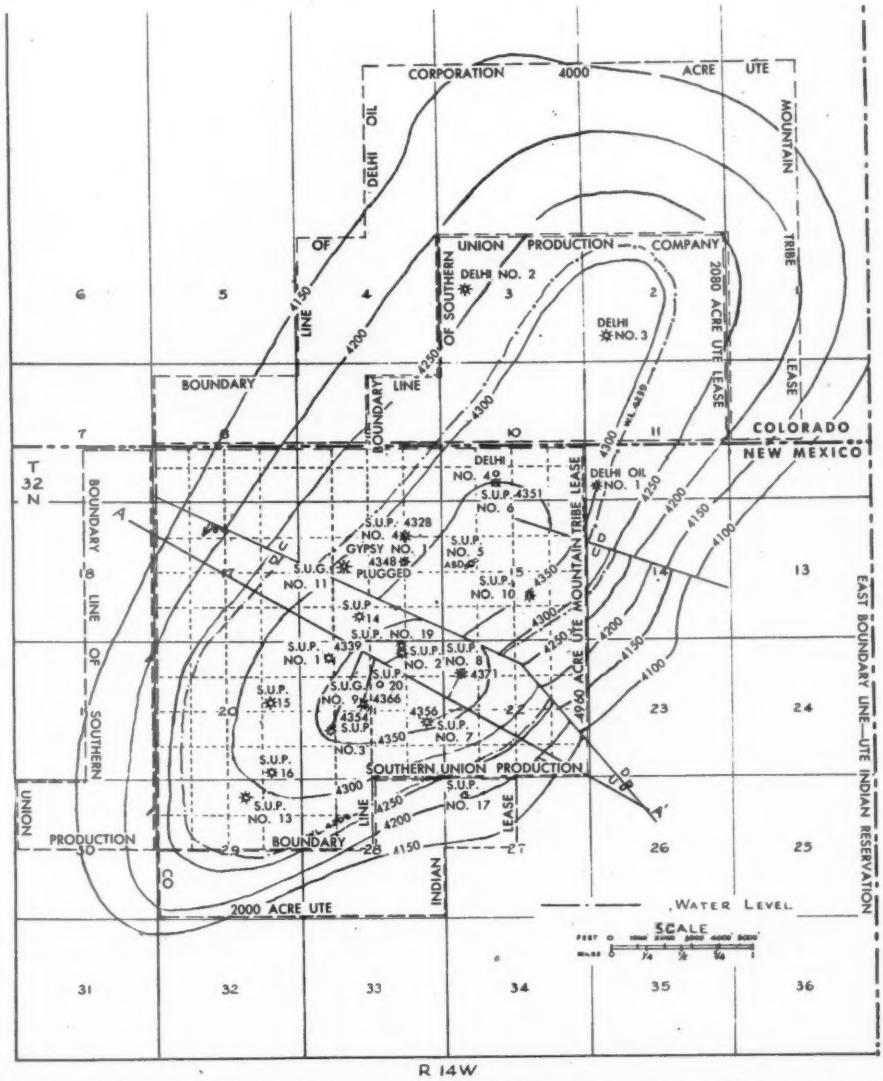


Blanco-La Plata field. The spudder, specially equipped, is used to drill through the Mesa Verde formation. The butane tanks, to the right, are for rig fuel requirements. Gas is used as a "drilling fluid" and this is pipe-lined to the rig at 200 to 400 psi.



Note: Ordovician probably present between the Devonian and Cambrian but not identified.

Generalized section of San Juan Basin.

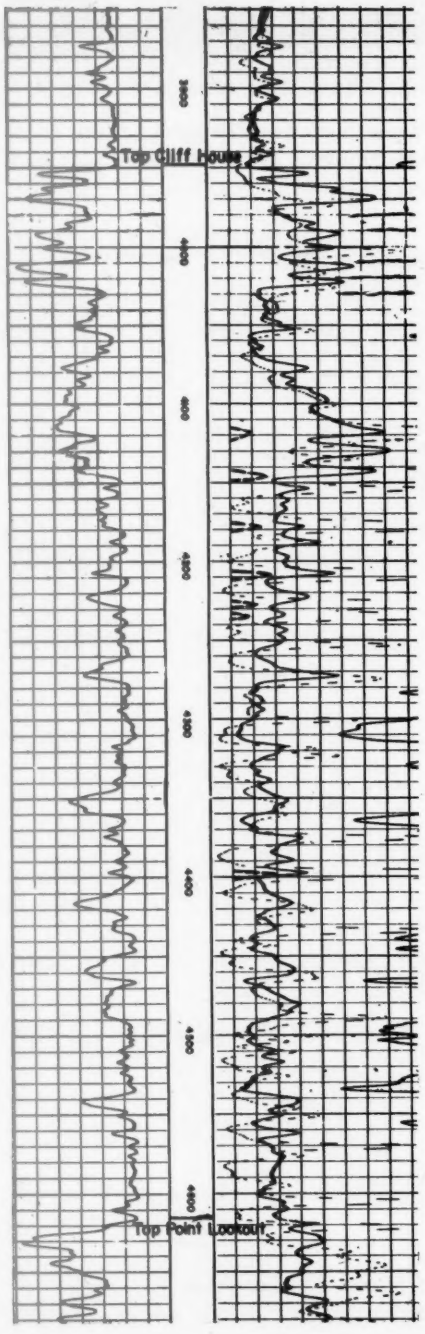


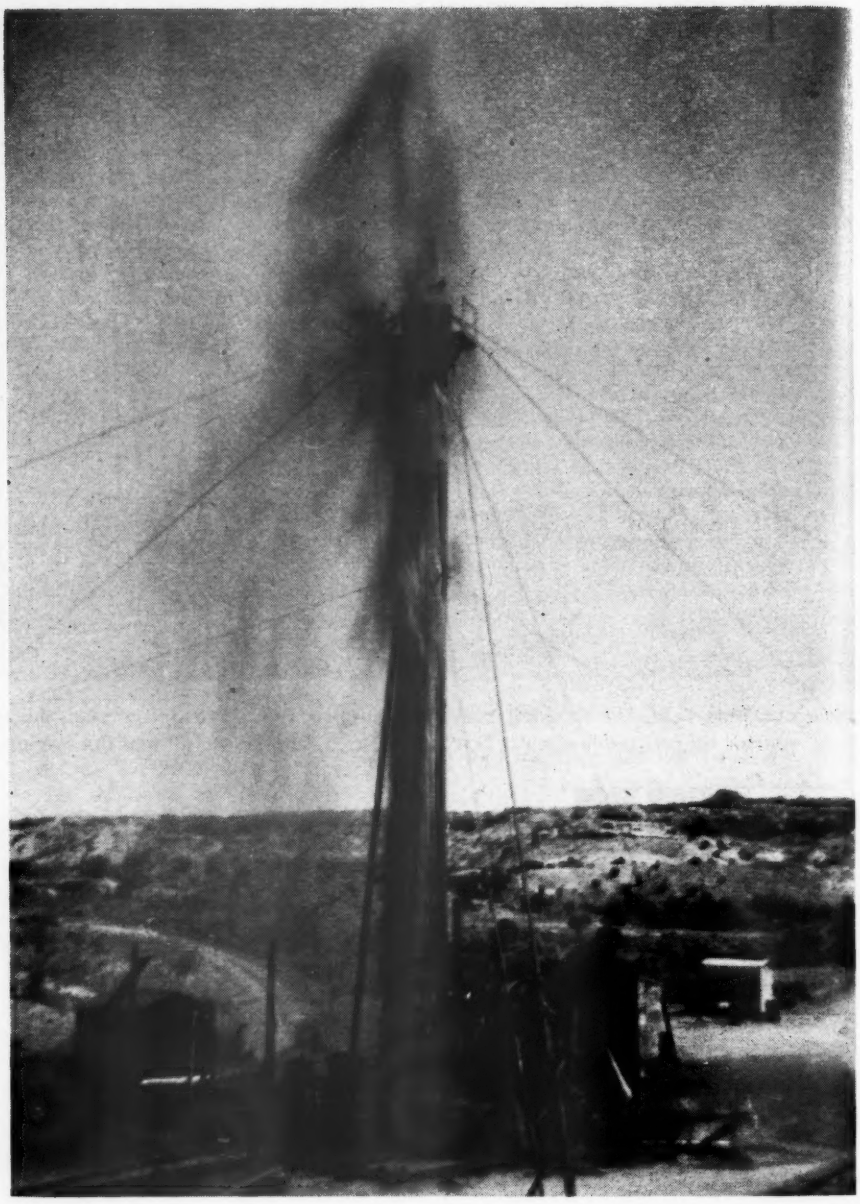
Southern Union Production Company plat of Barker draw anticline, San Juan County, New Mexico. Gas well spacing. Producing horizon, Dakota sand.

top of the pay because immediately above it is a water-bearing coal seam, which must be cemented off. By means of ratholing ahead and electric logging the sand is precisely located. To insure a good water shut-off, 5½-in. casing is set near the top of the Pictured Cliffs sand.

The mobile jack-knife type rotary is then moved off location and is replaced by a mobile cable tool rig to drill through the pay zone. The switching of rigs is done because of the economical aspect. On reaching total depth the well is filled with water and loaded from the bottom with 200 quarts of nitroglycerin to within 10 ft of the 5½-in. casing shoe.

Electric log of Cliff House sand on top of Point Lookout sand in the Blanco-La Plata field.





Shooting the well in Blanco-La Plata field. The producing formation is shot with 1800 quarts of nitroglycerine without any protective seal covering the charge. This method has proved very successful for producing the tricky Mesa Verde formation.

A seal[1] is placed on top of the explosive; the seal itself extends some 50 ft up into the casing, which, of course, acts as a protector during the explosion.

After firing the charge the well is cleaned out and a 1-in. siphon line with three 3/16-in. jet nipples is run in to enable the occasional requirement of blowing off the well to the atmosphere and so clean out any accumulated condensate and/or gasoline. The well is produced open-hole (barefoot) and on the 5½-in. casing.

Gas as a "Drilling Fluid"

In the Blanco-La Plata field the standard well spacing is 320 acres per well. There are 200 gas wells in this field, and Southern Union Gas Company has plans for the drilling of at least 100 additional wells.

[1]Calseal.

At 200 ft the surface casing is set and at 4000 ft a 7-in. string is cemented on the top of the Cliff House sand. Down to this point a normal rotary drilling procedure is followed. The rotary rig is then replaced by a specially equipped cable tool rig;[2] the 7-in. casing is left standing cemented during this rig change-over. When the cement plug is drilled out the well is unloaded until it is absolutely dry. High pressure gas, 200+400 psi, is connected to the drilling system, and tubing is employed instead of drill pipe. The gas is circulated down through the tubing and up the tubing-casing annulus to the atmosphere; the gas requirement is 1 to 2 million cubic feet daily. The well is

[2]Guiberson, type J, rotating drilling head powered by Waukesha engine fitted with fluid coupling attached to a 4-speed forward and 1 reverse speed transmission.

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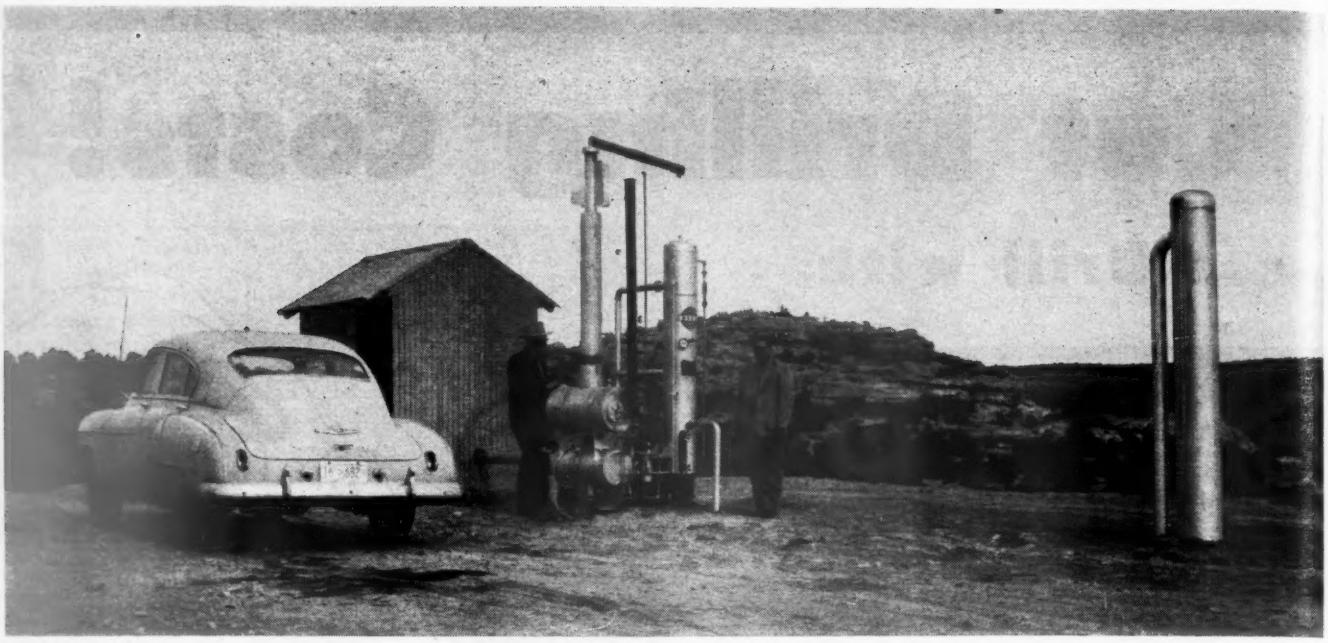


Drip, dehydrator and meter house, Florence Federal No. 6, Blanco field, in the San Juan Basin. At the dehydrator are T. A. Wilson and V. W. Bates. Dehydrators are necessary on all Blanco field wells.

drilled to a total depth of about 4800 ft into the base of the Point Lookout sand. Next, the bore hole is filled from the bottom to within 50 ft of the 7-in. casing with approximately 1800 quarts of nitroglycerine. In this method no protective seal is placed on top of the charge, instead the well is left open to the atmosphere and fired.

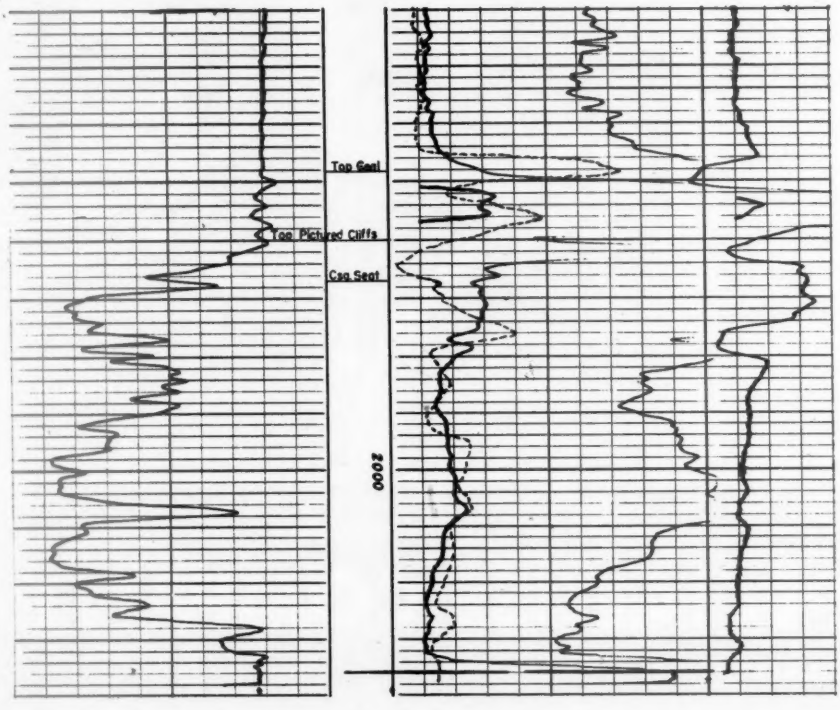
The reasons for employing the above method is that it was found that these formations would not produce when drilled with mud, due to the invasion of the pay zones by the drilling fluid. The practice of drilling-in with cable tools did not prove satisfactory because it sometimes took as much as 100 days to drill the 800 ft section at an exorbitant cost. But by drilling this same 800 ft with a rotary and gas as the fluid medium the interval is penetrated in as little as only 27 hr and with the use of 2 rock bits.

When drilling with gas, fire is a serious threat to safety and special precautions are taken to minimize the risk.

An average initial open flow well potential is 3,500,000 cu ft per day and a well has stabilized production after 3 months at the rate of 700,000 cu ft of gas per day.

Very little well maintenance has been necessary, but sometime in the future trouble may develop due to the disintegration of the formations, and screened liners will most probably have to be installed.

Electric log showing importance of having a good casing seat to shut off the water-bearing coal seam lying above the Pictured Cliffs sand in the Kutz-Fulcher field.



Limestone Production

In the Barker Dome field, where drilling is done with the rotary rig, 13⅜-in. casing is set at 300 ft. The Dakota gas zone is shut off by cementing 9⅝-in. casing at 3050 ft.

A 7-in. casing string is set on the bottom of the Paradox limestone, which is at 9100 ft. This vugular, dolomitic Paradox is selectively perforated and acidized, and the well is produced with the tubing set on bottom.

Due to the corrosive nature of the produced gas it is necessary to restrict production to the tubing, which allows the operator to produce about 12,000,000 cu ft per day per well, whereas an average open flow well potential is 50,000,000 cu ft per day. The injection of corrosion inhibitors[3] into the well has greatly aided in combating the trouble, and has enabled the production to be maintained at its present rate.

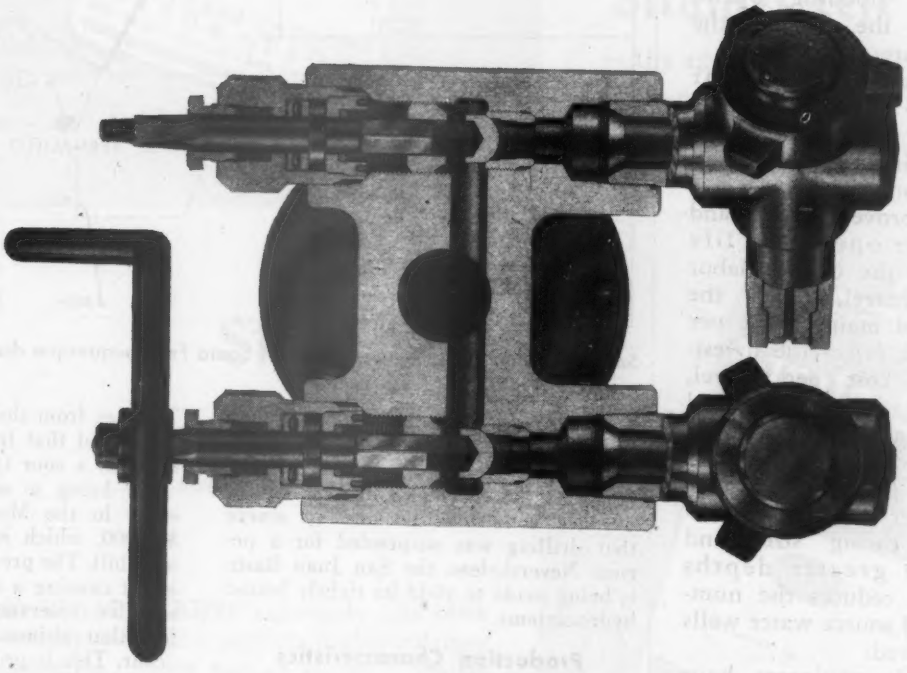
Field Conditions

Field operations in the San Juan Basin are difficult under the best of conditions. Roads are hard to maintain as many canyons, both large and small, abound everywhere. The scarcity of water is a problem all its own, and in

[3]Kontol.

pace DUAL

FLOW CONTROL



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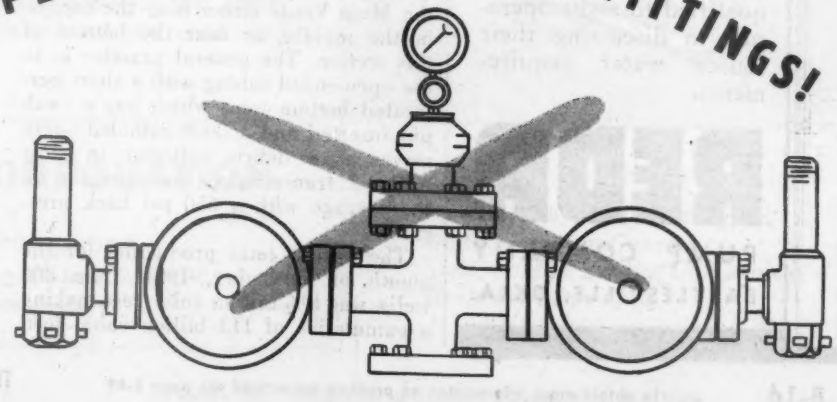

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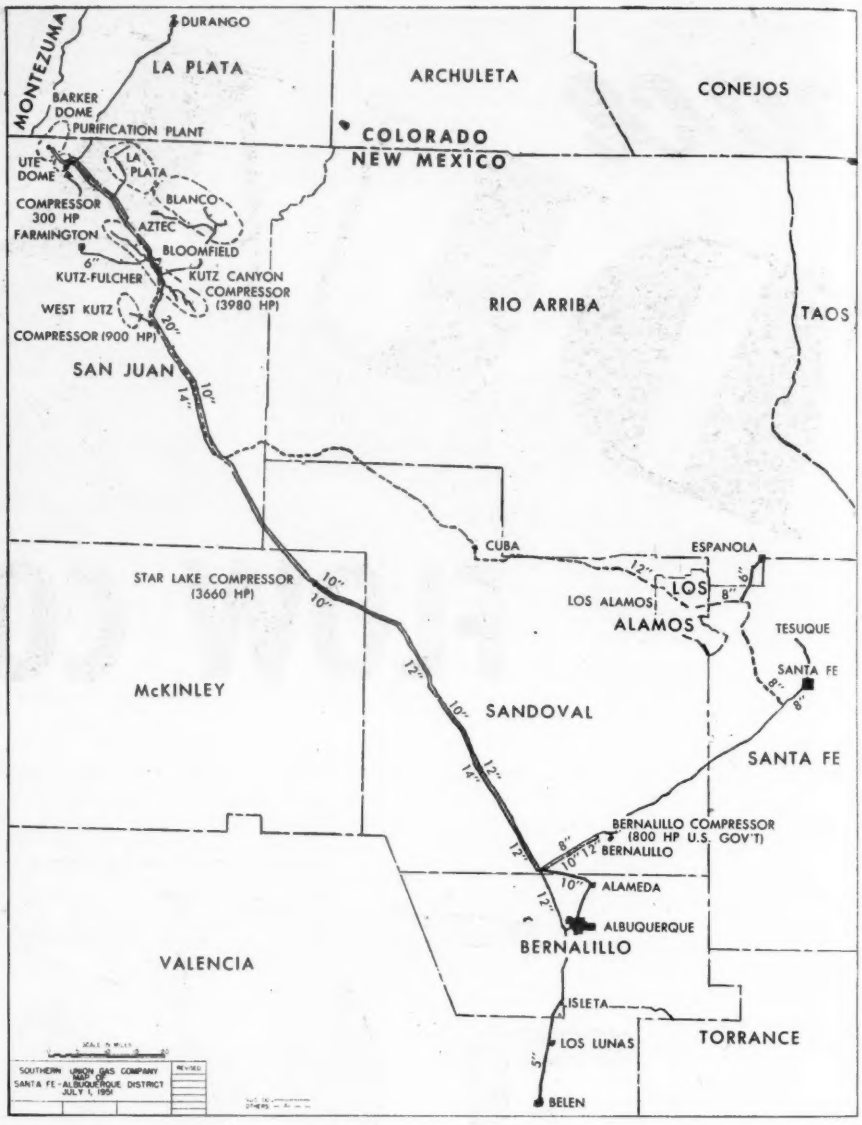

Southern Union Gas Company map of Santa Fe-Albuquerque district, July 1, 1951.

many instances arrangements are made for hauling it many miles to a drilling site.

During the early part of 1952 winter weather conditions became so severe that drilling was suspended for a period. Nevertheless, the San Juan Basin is being made to yield its tightly bound hydrocarbons.

Production Characteristics

The setting depth for the tubing presents the usual controversy, and each producer has his own idea. Consequently tubing is set, for example, in the Mesa Verde either near the top, or in the middle, or near the bottom of this section. The general practice is to use open-ended tubing with a short perforated bottom joint which has a swab pin inserted and a 50-ft ratholed sump serves as a debris collector in most wells. A transmission line operates on the average with a 650 psi back pressure.

The basin's total production for the month of December, 1951, from 300 wells, was 8½ billion cubic feet making a cumulative of 113 billion cubic feet. The gas from the Mesa Verde sands is sweet and that from the Paradox limestone is a sour type.

To bring a well to the producing stage in the Mesa Verde costs about $80,000, which includes $4000 for the mud bill. The present rate of withdrawal is not causing a serious drop in the respective reservoir pressure, but some fear that ultimately rapid decline may occur. This is problematic and the matter is under constant review. The average wellhead tubing pressure, by dead weight tester, from the Mesa Verde formation is 1100 psi.

Oil production in the basin has not been on a large scale to date, but possibilities exist and they are being explored.

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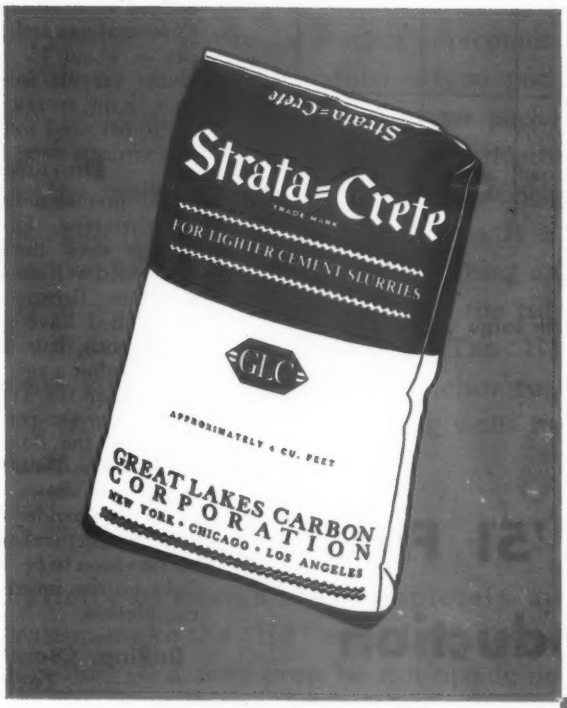

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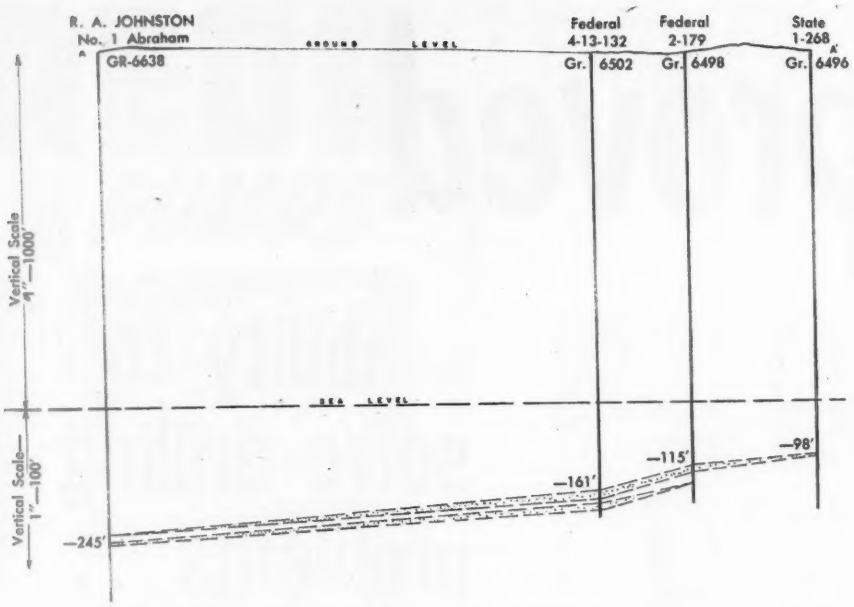


FIG. 1. Cross section of Tocito sandstone, South Largo Canyon area, New Mexico, along line A-A of Fig. 2.

San Juan Basin '51 Find Is Good Oil Production

Something has been added to lush gas reserves —44 gravity sweet crude oil from Tocito sand

HENRY S. BIRDSEYE

ALTHOUGH the San Juan Basin in northwest New Mexico has for nearly 30 years been the scene of prolific gas production, the prospects for oil development have not offered encouragement to compare with the gas reserves in the Pictured Cliffs, Mesa Verde, Dakota, and Paradox zones. With a few minor exceptions, the only noteworthy oil discoveries until recently were the old Hogback, Rattlesnake, and Hospah fields, with a total cumulative production of some 10,000,000 bbl. The quest for oil was suddenly revived in July, 1951, when Thomas W. Doswell, Todd M. Pettigrew, and associates achieved substantial production from the Tocito member of the Mancos shale. The discovery well, Doswell and Pettigrew et al Federal Scott No. 2, in Section 10, Township 26 North, Range 6 West, flowed 20 bbl per hour on an 11½-hr drill stem test, touching off a flurry of drilling in the South Largo Canyon area. Subsequently, the same area has proved to possess large gas reserves in the Pictured Cliffs sandstone and Mesa Verde section, apparently extending the vast Fulcher-Kutz and Blanco trends that have yielded great quantities of gas over a period of many years.

Stratigraphic Relations and Lithology

There is some doubt as to the accuracy of designating the oil sand as "Tocito," due to its erratic nature derived from lenticular sedimentation. Such a scant number of deep tests has been drilled in the Basin that correlation over a wide area is prohibited. Variously described as Hospah, Gallup, or Juanalopez in age, it would probably be more correct to refer to the oil zone as "Tocito equivalent" rather than "Tocito," which might be taken to imply a widespread continuity not supported by the facts currently at hand. For the sake of brevity, however, the writer will employ the common designation "Tocito" in this paper.

At an average depth of 6700 ft in the Pettigrew field, the Tocito sandstone is near the base of the black, marine, fossiliferous Mancos shale of Cretaceous age. The top of the Dakota sandstone lies about 600 ft below the Tocito. In the wells thus far drilled, the Tocito sand varies in thickness from 4 to 42 ft. A shale break with a maximum thickness of 13 ft generally separates the two main sand members, although in several instances the lower sand has been absent. The pay itself is a medium-grained, loosely-cemented, sub-angular to angular glauconitic sandstone, interbedded with several thin shale streaks. Core analyses indicate an average porosity of about 15 per cent, and permeability varying from .5 md in the lower part to an average of some 135 md in the upper sand zone.

Structural Influence

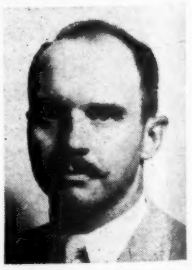
The precise nature of the trap is still undetermined. Gravity and magnetic surveys show anomalies in the vicinity that could well result from a deep-seated structure. Because the deep tests thus far drilled have trended more or less north-south, it is not possible to ascertain whether a reversal of dip is present, or whether the Tocito merely conforms roughly to the regional dip toward the center of the Basin about 25 miles to the north-northeast. As the accompanying section shows, sufficient lensing prevails to provide a stratigraphic trap should structural control be lacking. Locations soon to be drilled will shed much light on the interesting problem of accumulation.

Drilling, Completion, Production Techniques

The development program in the Pettigrew field has thus far concentrated on Pictured Cliffs gas wells, drilled to an average depth of 3000 ft. Twenty-five of these wells have been completed and, with the exception of those supplying fuel for the camp and drilling rigs, all are shut in pending completion of an 8-in. gas line by Southern Union Gas Company. Five deeper wells have been drilled, and one more is nearing completion. The two original deep tests were carried to the Morrison formation, but were not completed commercially due to large flows of water in the Morrison and discouraging quantities of gas and

The Author

Henry S. Birdseye is a geologist for Lowrey et al Operating Account, oil producers. A native of Massachusetts, he attended Harvard College, from which he was graduated in 1950 in geology. He then roughnecked several months for Kerr-McGee Oil Industries, Inc., and later became a geophysicist for Stanolind Oil and Gas Company. He joined Lowrey in September of last year.



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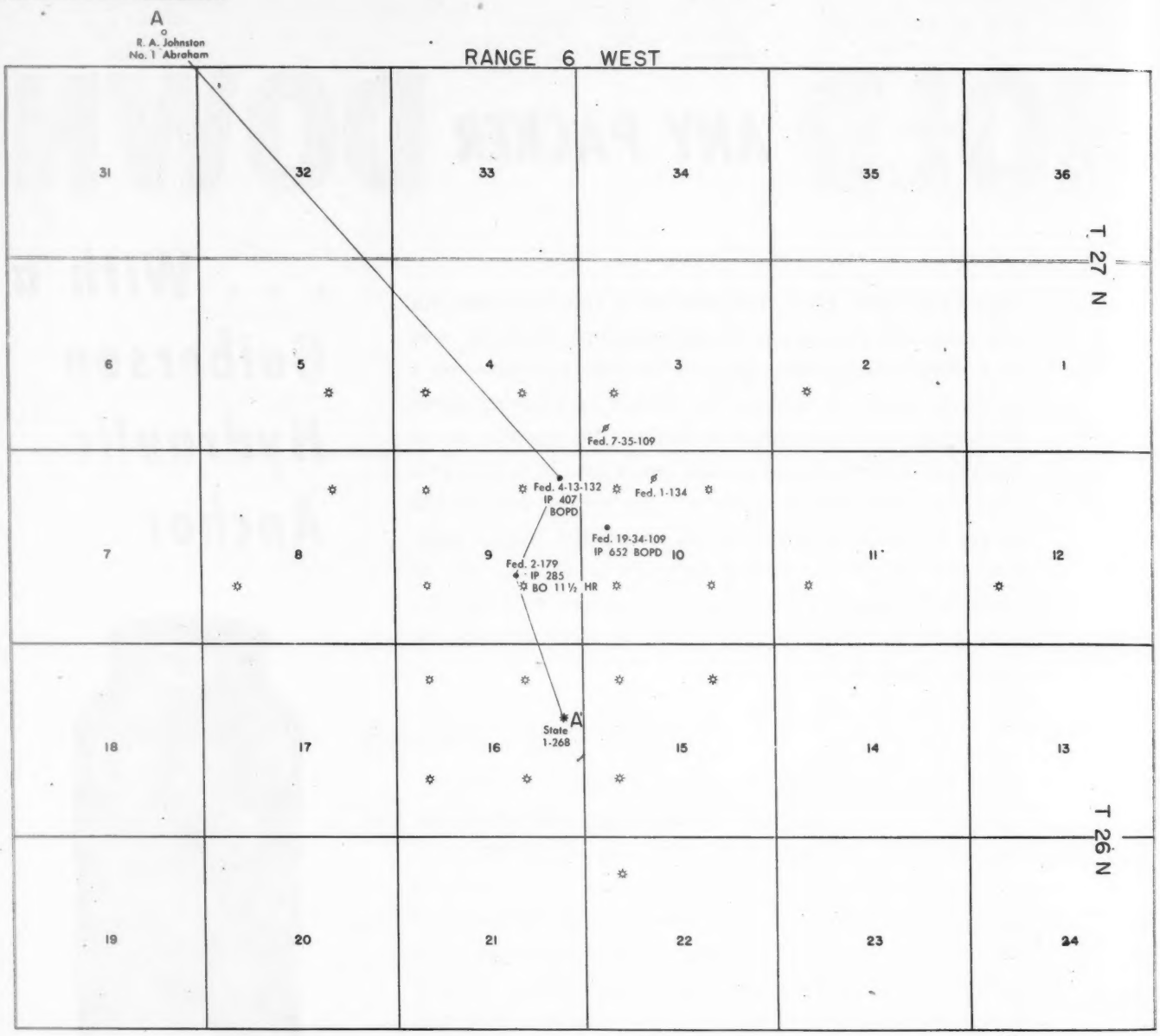

FIG. 2. Lowry et al oil and gas field, South Largo Canyon area, New Mexico.

oil in the overlying Dakota. Following the discovery of oil in the Tocito, one of the deep tests was plugged back to the oil sand and attempts are under way for completion. The discovery well, plus a second completion with an initial production of 407 bbl in 24 hr, and a third well came in with an initial production of 652 bbl per day, and are all producing, supplying 44-gravity sweet green crude to the Petroleum Products Refining and Producing Company refinery at Prewitt, 100 miles to the south. The problem of hauling oil becomes a major one during the inclement winter months, as the entire distance to be traversed consists of dirt roads that frequently wash out or are converted into deep mires. There is the further disadvantage of crossing Largo Canyon, which drains much high country to the east, and is transformed into a raging torrent that has been the nemesis of several unhappy drivers.

It is necessary to case off the sand that provides water for the camp and drilling operations. And a typical drilling program calls for 10¾-in. surface casing cemented at about 550 ft with 300 sacks of cement. Casing is set 8 ft above the Tocito with 200 sacks cement. The Tocito pay is completed open hole.

(The Point Lookout sand at the base of the Mesa Verde, would be completed for gas in the absence of oil from the Tocito.) The slender margin between a contractor's profit and loss frequently depends on the foresight of his mud program. Several shallow bentonitic shales must be penetrated, as must a lost circulation zone at the base of the Mesa Verde. A low-water-loss mud is mixed as soon as the surface casing plug is drilled, and lost-circulation material is added as the lower Mesa Verde is drilled. Because of considerable lost circulation in the oil sand a low water loss drilling fluid is required and an oil-emulsion mud is used. Satisfactory electric logs and micrologs have been recorded after drilling the pay. Two previous experiences with conventional low-water-loss water-base mud had resulted in costly swabbing operations to extract the mud that had invaded the oil zone to a considerable depth. It is expected that a light-weight, high-viscosity, low-water-loss oil emulsion mud will reduce this expensive completion difficulty.

Experience has demonstrated that approximately the following numbers of bits are required in a typical Tocito well: One 13¾-in., thirty to forty 8¾-in. or 9⅞-in., and one 6¼-in.

Although it would be premature to predict the extent of Tocito development in the South Largo Canyon area at such an early stage, it is certain that the interest that has been focused on the region has stimulated exploratory drilling throughout the Basin, with the strong possibility that other deep production will be uncovered by the probings of the bit. * * *

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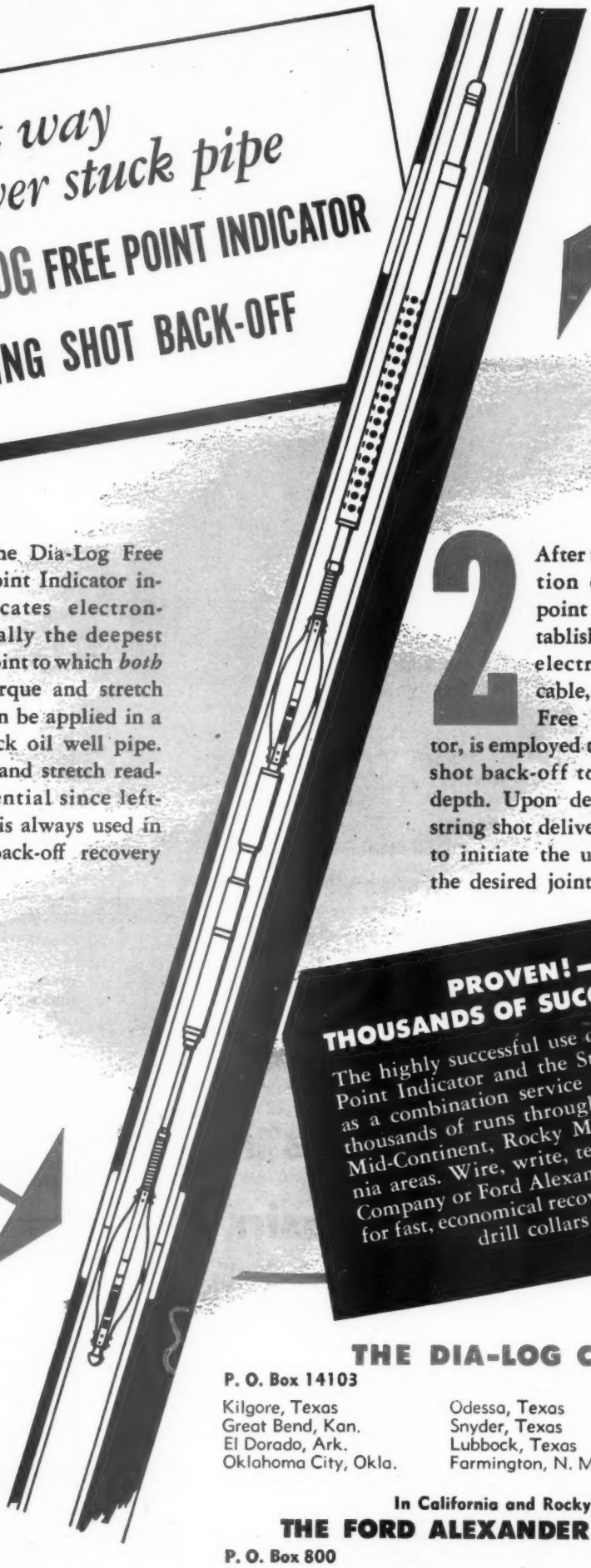

1 The Dia-Log Free Point Indicator indicates electronically the deepest point to which *both* torque and stretch can be applied in a string of stuck oil well pipe. Both torque and stretch readings are essential since left-hand torque is always used in subsequent back-off recovery operations.

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Winter location in the San Juan Basin shows snow covering the range terrain.

Vast distances, poor communications, lack of highways, and extremes in weather hinder

Service Operations in the San Juan Basin

HUGH J. AYRES

THE greatest obstacle facing any operation in the San Juan Basin is a combination of time and communication. Of similar importance is the terrain and the weather. These factors become critical for a service company.

Oil and gas production in the San Juan Basin is a far-flung operation. A circle enclosing proved production in the area would have a diameter of approximately one hundred miles. Driving from one edge of this imaginary circle to the other over the existing road system means traveling a much greater distance. If we express this distance in terms of the time consumed in moving a piece of heavy equipment, it takes on a staggering value. Distance for a service company is essentially a matter of time.

The area is very sparsely settled with the result that there are almost no improved roads off of the few highways and very few points from which telephone calls can be placed. Many companies are installing radio communication in order to facilitate their operations.

The surface of the basin varies from a rolling plain to mountainous terrain with abrupt changes in elevation characteristic of the western states. At one particular well location it is possible to toss a rock and have it fall over a thousand feet before it strikes the access road leading to the well.

Winter brings varying quantities of snow with virtual isolation of some of the northern fields. Lowest temperatures are more than 50 deg below zero. Spring thaws bring muddy roads and swollen streams with added inaccessibility. There is a location in Utah that is about 150 miles from Farmington, New Mexico, normally. During winter months it is necessary to drive more than 500 miles to reach it.

There is a fine spirit of cooperation between the producing operators in the field and the service companies, which helps to overcome these problems of terrain and weather.

Cementing

The casing program on shallow and medium depth wells generally includes two strings of casing. The production string is set above the pay and the well is completed from open hole. Bulk cement is not yet available in the area and a relatively small amount of sack cement is used for each job.

On the shallower wells of 1200 ft to 2000 ft, a simple cement job is sufficient. In cementing the production string of casing on the Mesa Verde wells, 3500 ft to 5000 ft, it is sometimes necessary to resort to multi-stage cementing, using a stage cementing tool. There is a lost returns zone just above the pay formation that makes it impossible to place a high column of cement behind the pipe in a single stage. The tool is placed in the casing string just below the shallower gas zone. The first stage of cement is run and allowed to set for 6 to 8 hr. Following a temperature survey to find the top of the cement, the tool is opened and the second stage is run.

On the deeper wells, casing is some-

The Author

Hugh J. Ayres is a district engineer for Halliburton Oil Well Cementing Company at Hobbs, New Mexico. He obtained his bachelor of science degree in mechanical engineering from Texas Technological College in 1948.

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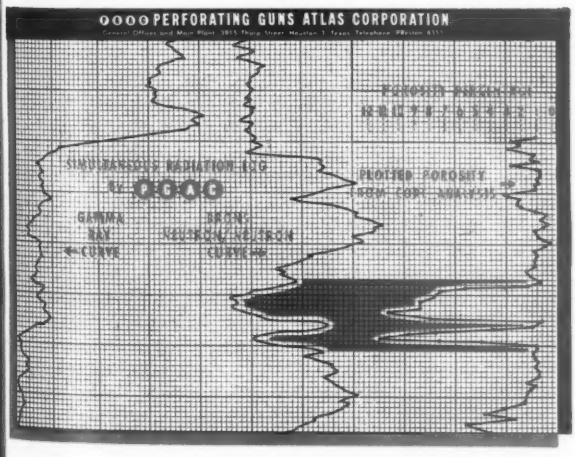

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times set through the pay formation and multiple stage cementing is occasionally used. This is dependent on the desired top of the cement behind the casing. Some producing companies use rotating abrading devices on casing to insure a better cement job.

Remedial cementing is accomplished with both retrievable and drillable cementing packers in most cases. Except for squeeze cementing perforations and repairing casing leaks, most such jobs are necessitated by setting casing too high or the occurrence of a coal stringer at a lower point than was anticipated. The shallower producing formations frequently have a vein of coal just above them, with an occasional stringer of coal occurring a few feet below the casing point.

Drillstem Testing

Drillstem testing in the San Juan Basin is generally confined to open hole tests in deep wells and wildcats. Shallower wells are usually drilled in with cable tools after setting casing.

In some areas long unconsolidated shale sections add to the difficulty of testing. Sometimes the shale collected in the bottom of the hole makes it impossible to get all the way into the hole. If the mud is poorly conditioned shale will settle on top of the packers after they are set and increase the possibility of getting the string of testing tools stuck. Proper mud condition is a must under these circumstances.

Dump Bailer

The major portion of the production is from sandstone formations. Most of the shallower wells are 'shot' with a heavy charge of explosive. This completion technique usually calls for confinement of the charge with a 'tamp' of quick-setting gypsum cement. An average of 800 lb of the cement is used and is placed with a dump bailer unit.

This same gypsum cement is used for temporary plug backs and bridge plugs when it is necessary to protect the pay while doing remedial work. Some experimentation is in progress on the use of a waterproof plastic cement to shut off bottom hole water. The plastic is put in place with a dump bailer and hydraulic pressure applied in order to force the material out into the formation in the form of a squeeze. Notable success has been achieved.

This same procedure has been used to squeeze the shoe joint of the production string.

Conclusion

The problems attendant to oil well cementing and other service operations in the San Juan Basin are on the average no more or less difficult than are experienced in many other oil producing areas. The remoteness of the area, involving great distances from supply points and the lack of good communication facilities add to the problem of operation in a way to place both the well driller and the service operator very much on their own.

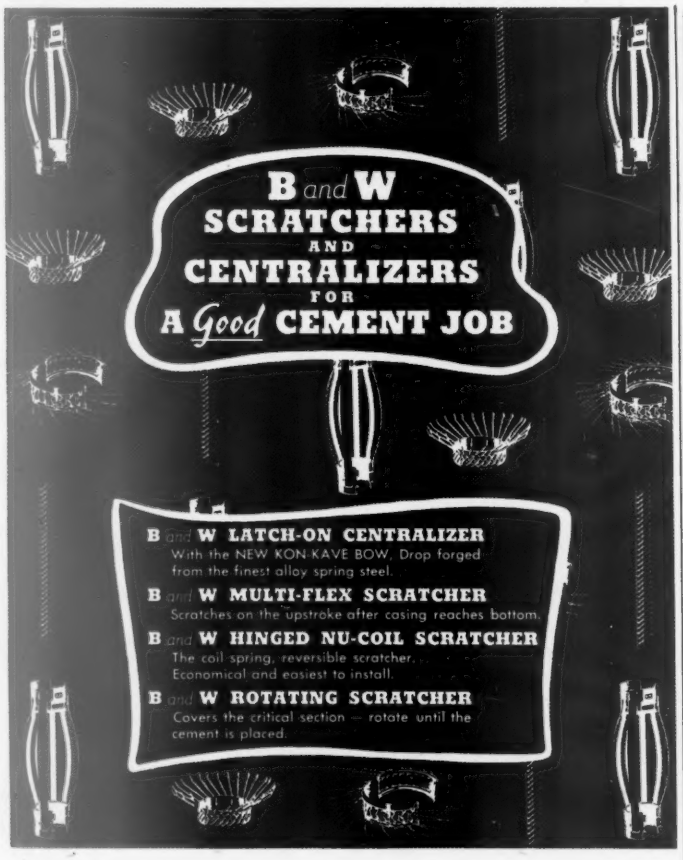
As drilling operations in this area increase, and it now appears they will, it is to be expected that more and better roads will be opened for better access. It is doubtful, however, if the winding and tortuous roads over considerable heights and into deep canyons will ever be improved to such a point that highway travel with heavy equipment can have the desired maximum of safety.

The area is quite truly a frontier province. It is already a proved area for large gas production and offers great possibilities for future oil production in view of the recent discoveries within the general region. As the area offers promise for considerable development, the oil man will get there somehow. * * *

Alaskan Map Out

The U. S. Geological Survey has published an oil and gas investigations map on exploration, drilling, and research in Naval Petroleum Reserve No. 4 and adjoining area in northern Alaska. The Arctic Slope of Alaska, including 37,000 sq miles of Naval Petroleum Reserve No. 4, lies between the Arctic Ocean and the Brooks Range, the northernmost mountains of the North American continent.

Map OM 126, consisting of three large sheets, presents geologic and related information obtained to 1950, and in addition shows locations of test wells drilled as of March 1, 1951.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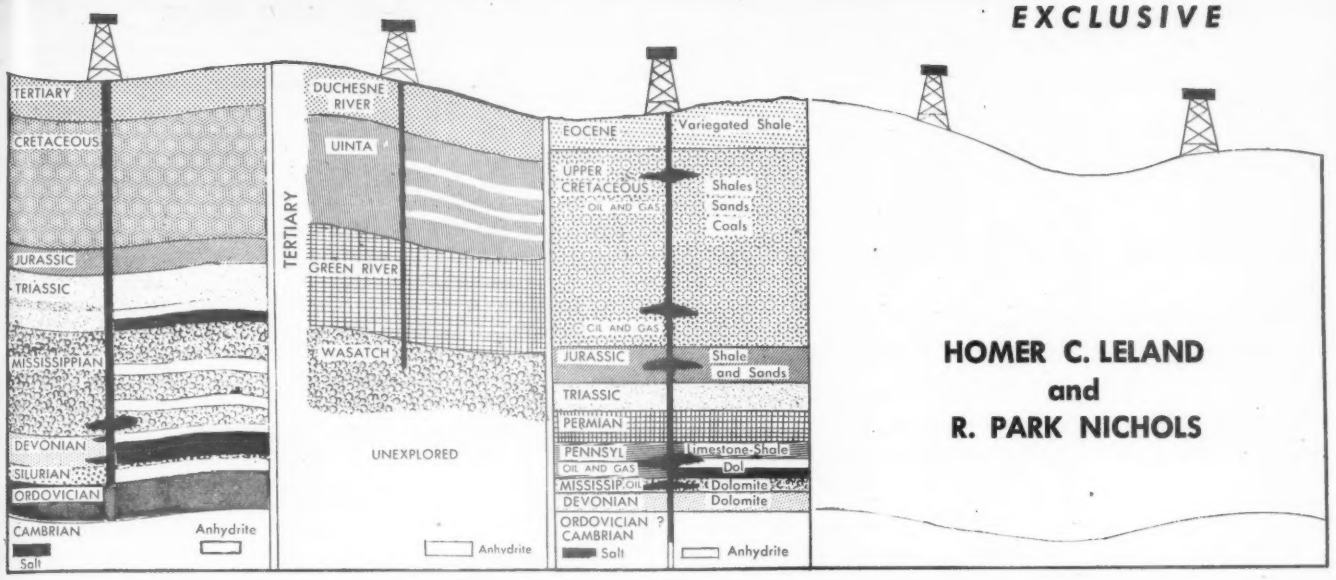

Drilling Mud Problems in San Juan Basin

HOMER C. LELAND
and
R. PARK NICHOLS

Loss of circulation, badly sloughing shales, blow-outs, and other problems are met by these mud engineering methods

PROPERLY controlled drilling muds are an important factor in overcoming many of the problems associated with drilling operations throughout the San Juan Basin. Badly sloughing shales, blow-outs, loss of circulation through the Upper Cretaceous formation along with anhydrite and salt in the Lower Pennsylvanian formation are the conditions affecting mud practices.

The San Juan Basin covers an area of more than 12,000 square miles. The larger portion of the basin is in northwestern New Mexico and southwestern Colorado. Smaller portions of the basin extend into southeastern Utah and northeastern Arizona. Most of the geological systems are present. Structurally the formations rise gradually from the deepest part of the basin toward the mountain uplifts surrounding the area. The basin is bordered on the north by the San Juan Mountains of southwestern Colorado; on the east by the Nacimiento Mountains of central New Mexico; on the south by Mt. Taylor and the Zuni Mountains; and on the west by the Defiance uplift and Carrizo Mountains, which lie along the New Mexico-Arizona border. The basin produces commercial oil and gas from formations of Pennsylvanian, Permian, and Upper Cretaceous Ages.

In drilling the upper part of the hole, trouble may be expected from the badly sloughing Lewis and Mancos shales of Cretaceous Age. This condition is usually overcome by adding bentonite, which provides the necessary mud viscosities to clean the hole. Barium carbonate or soda ash is added to precipitate the calcium ion present in the gypsum contaminated make-up waters. Combinations of caustic soda and chemical thinners such as quebracho, are added to lower the filter loss of the mud and help control gel strengths.

A much greater problem through this section of the hole is the loss of circulation in the Mesa Verde formation. All types of bulky materials are used to reestablish circulation. Common among these are the fibrous and cellophane type materials along with cotton seed hulls. In some cases an additional problem is presented by attempted well blow outs from the shallower Fruitland or Pictured Cliffs gas formations. These attempts occur when the fluid level falls in the well during periods of lost circulation. Reduction in fluid level height reduces the hydrostatic pressure on the formation. Occasionally weighting material is added to the mud to provide the neces-

The Authors

H. C. Leland

R. P. Nichols

Homer C. Leland was born and reared in the oil fields of Oklahoma. He attended Oklahoma University and graduated in January, 1948, with a B.S. degree in petroleum engineering. His education was interrupted by a three-year tour of duty in the U. S. Navy. In May, 1948, he joined Baroid Sales Division as a field service engineer and since that time has worked with drilling muds in Kansas, Colorado, Canada, West Texas, New Mexico, Arizona, and Utah.

R. Park Nichols was born in McClellan County, Texas. He enlisted in the U. S. Marines from school and spent four and one-half years in the service. He has experience working with drilling muds in Montana, Wyoming, North Dakota, Colorado, Utah, and Arizona. For the past two years he has been a mud engineer in the San Juan Basin of New Mexico.

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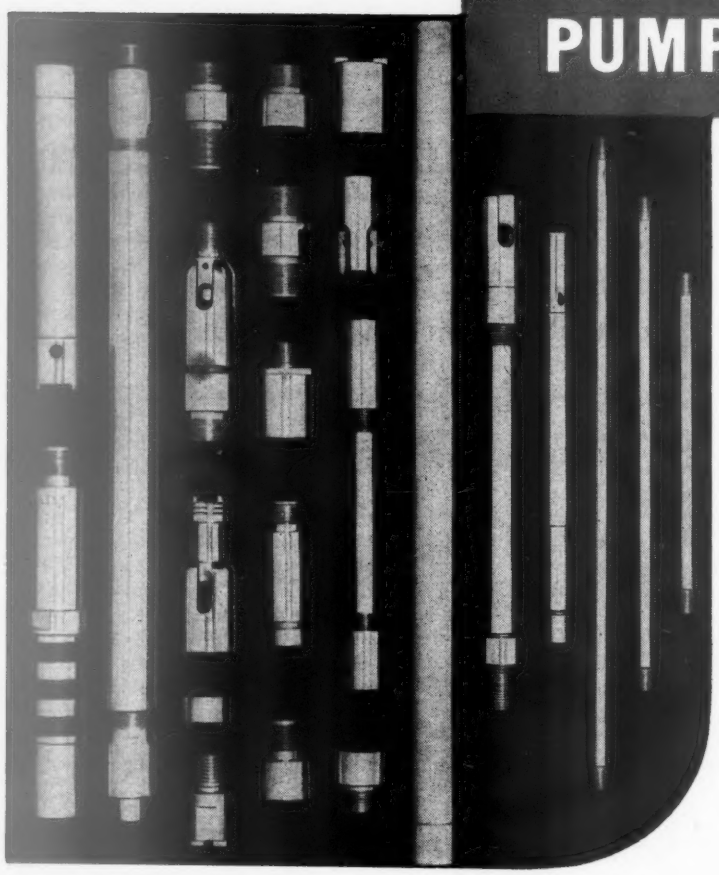

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San Juan Basin

Two representative muds of the San Juan Basin are as follows:

	Fresh Water	Salt Water
Weight—pounds per gallon	9.1	10.0
Viscosity—Secs., API	42	67
Initial Gel—Grams, Stormer	0	8
Ten Minute Gel—Grams, Stormer	12	22
Filter Loss—cc, API	7.8	6.0
pH	8.5	6.0
Salt, ppm	Nil	197,000
Preservative—pounds per barrel	—	.25

sary weight to control formation pressures along with sufficient bulky material to prevent mud loss to the formation. In all cases a mud weight is sought that gives a balance between the weight necessary to control formation pressures and below that which will cause loss of circulation. This ideal mud weight cannot always be accomplished and in extreme conditions casing-off of the shallow gas formations is required. Loss of circulation also occurs in the thin coal section immediately above the Pictured Cliffs formation but this is usually handled successfully by either lowering the mud weight or by adding bulky materials to the mud.

In the northwestern part of the basin, anhydrite and salt are found in the Paradox formation of Pennsylvanian Age. In this area loss of circulation is not a problem and the mud contaminants are easy to control. Where salt is encountered it is found below the anhydrite. In those areas where the salt is not present, the anhydrite zone is drilled with a fresh water mud treated with barium carbonate. This treatment removes the contaminating calcium and sulfate ions. Barium carbonate reacts with the calcium and sulfate ions forming the insoluble precipitates calcium carbonate and barium sulfate.

When salt is anticipated the mud system is converted at the top of the Paradox formation and the anhydrite and salt sections are drilled with a saturated salt water mud. Salt water muds are prepared by adding rock salt in sufficient quantities to saturate completely the base mud. Special salt water clays are added to produce the necessary viscosities required to clean the hole and starches are used as a filter loss control agent. With a salt water mud the anhydrite and salt zones are drilled without noticeably effecting the mud. Saturating the mud with salt also prevents solution caverns through the salt section. Preventing such caverns prevents conditions which favor twist-offs and bad fishing jobs. If, after drilling through the salt, the salt concentration in the mud drops below the saturation point preservatives are added to prevent fermentation of the starch. * * *

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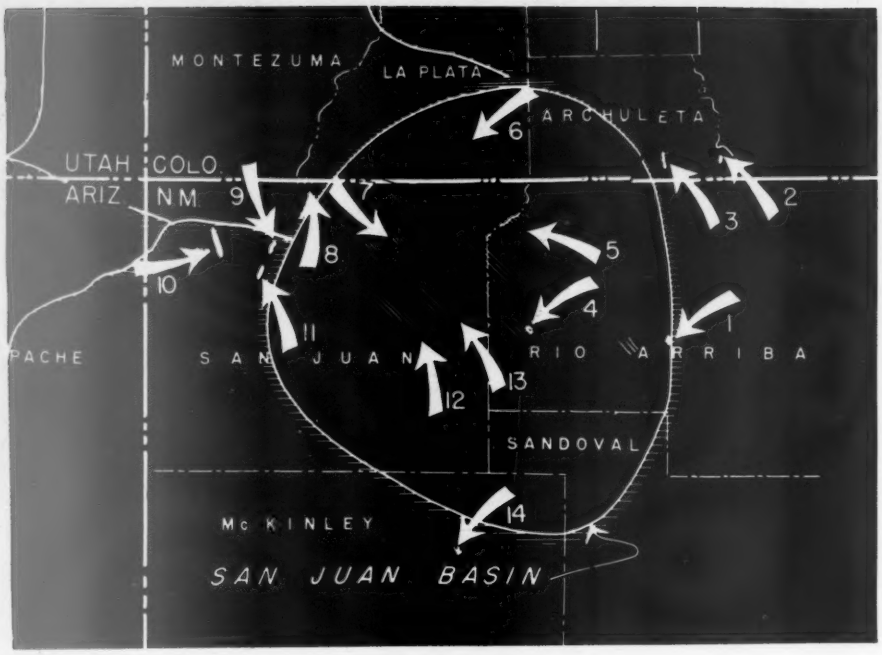

FIG. 1. Oil and gas fields of the San Juan Basin.

Exploration Expands in Four Corners Region

Geophysical activity and exploration drilling are breaking out all over San Juan, Paradox, and Black Mesa Basins of Colorado, New Mexico, Arizona, Utah

PAUL H. UMBACH

Oil and gas fields (Fig. 1).

Map Index No.	Field name	Producing formation	Age	Gas or oil	Depth, ft
1	No name	Tocito	Cretaceous	Oil	2900
2	Hughes (Gramps)	Dakota-Morrison	Cretaceous-Jurassic	Oil	1300
3	Chromo	Tocito-Greenhorn	Cretaceous	Oil	400-600
4	Dogie Canyon	Tocito	Cretaceous	Oil	6700
5	Blanco	Mesaverde	Cretaceous	Gas	5000
6	Ignacio	Fruitland	Cretaceous	Gas	2500
		Dakota-Morrison	Cretaceous-Jurassic	Gas	7800
7	Astec	Pictured Cliffs	Cretaceous	Gas	2000
8	Barker Creek Dome	Dakota	Cretaceous	Gas	2900
		Paradox	Pennsylvanian	Gas	9000
	Ute Dome	Dakota	Cretaceous	Gas	2900
		Paradox	Pennsylvanian	Gas	9000
9	Hogback	Dakota	Cretaceous	Oil	750
11	Table Mesa	Dakota	Cretaceous	Oil	1300
		Leadville	Mississippian	Oil	8100
10	Rattlesnake	Dakota	Cretaceous	Oil	1300
12	West Kutz Canyon	Pictured Cliffs	Cretaceous	Gas	2000
13	Kutz Canyon	Pictured Cliffs	Cretaceous	Gas	2000
14	Hospah	Hospah	Cretaceous	Oil	1600

THE Four Corners area obtained its name from the corner common to the states of Colorado, Utah, Arizona, and New Mexico, and by a coincidence the same corner is the approximate location of the joining of the San Juan, Paradox, and Black Mesa Basins.

Geophysical

In 1945 and 1946 many companies and independents completed magnetometer and gravity meter surveys. As early as 1947, however, the use of seismograph predominated. It will be noted in the San Juan Basin (Fig. 2) that only 52 crew weeks were completed in 1946. In 1947 and 1948 the number of crew weeks was increased to approximately 250. The year 1949 was a recession in geophysical activity (Fig. 2) due to the lack of assurance of a pipe line outlet. In July 1950, the Federal Power Commission approved the El Paso Natural Gas Company application for a 24-in. natural gas pipe line to California. This caused an increase in the geophysical activity to 200 crew weeks in 1950 and 276 crew weeks in 1951 in the San Juan Basin (Fig. 2).

As noted on Fig. 2, the Paradox and Black Mesa Basins had received only a small amount of geophysical activity until 1950, at which time there was an increase caused by a reef play in the southern end of the Basin.

The Black Mesa Basin received a very small amount of seismograph work, with no activity since 1949.

The Author

Paul H. Umbach, consulting geologist in Albuquerque, New Mexico, graduated from the University of Wyoming in 1932 with a BS degree in geology and obtained his MS degree in geology at the University of Wyoming in 1935. He completed one year of graduate work on his Ph.D. at the University of Missouri in 1940.

From 1935 to 1940 he was instructor of geology at Southern College, Magnolia, Arkansas. He did geological work with Stanolind Oil and Gas Company in West Texas, East Texas, and the Texas Panhandle from 1941 to 1945. From 1945 to 1952 he was district geologist with the Stanolind Oil and Gas Company in Albuquerque, New Mexico, concentrating his interest in the Four Corners area.

In 1952 he was elected vice president of the Rocky Mountain section of the American Association of Petroleum Geologists. He is also author of the annual development paper for Arizona and Northern and Western New Mexico for the Bulletin of the American Association of Petroleum Geologists from 1947 to 1949, and co-author of the same paper for 1950 and 1951.

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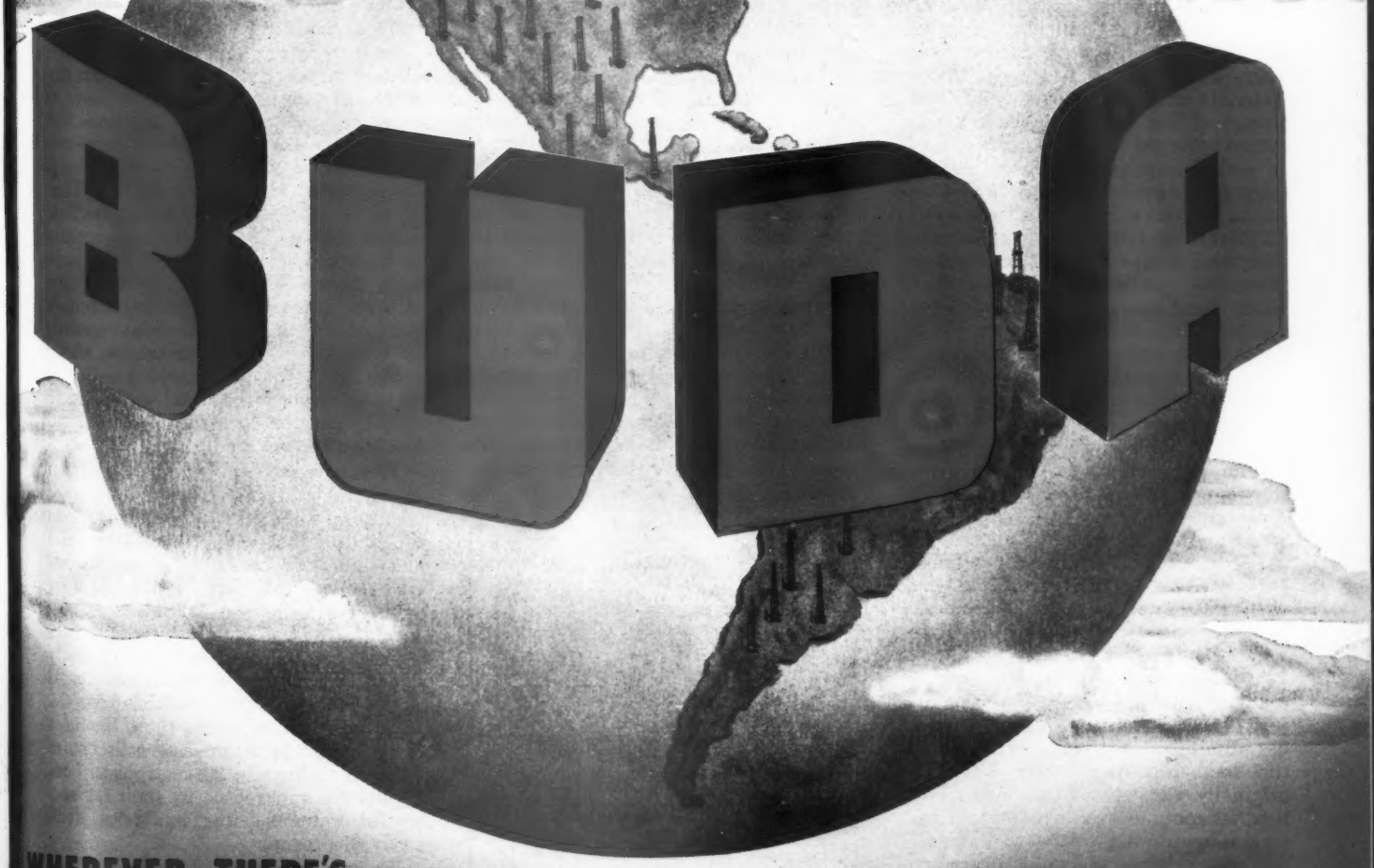

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CALIFORNIA WATER FLOODING

Increased demand on West Coast has cut margin between production and supply and calls for application of secondary recovery methods

N. VAN WINGEN

FOR many years California engineers have followed with interest water flooding operations that were being conducted in the Mid-Continent and eastern sections of the United States. Seven years ago, the Pacific Coast District Topical Committee on Production Technology of the American Petroleum Institute surveyed the literature and made a preliminary survey to ascertain to what extent procedures as followed east of the Rockies might lend themselves to California operations.[1] It is to be noted that these studies as well as the present discussion consider only secondary water flood operations or those where water is injected for the purpose of augmenting native reservoir energy after a pool has approached its economic production limit by primary recovery methods.

At the time the API study was made, California's primary production capacity was considerably in excess of market demands. According there was little interest on the part of management to engage actively in secondary operations. During World War II years, West Coast crude oil shortages developed but it was believed that termination of hostilities would again return the demand to near its pre-war value. The latter condition did not develop, however, as the majority of the war-time labor remained in California and was absorbed in peacetime industries. As a matter of fact, the originally war-induced westward migration has continued to the point that barring a major depression or extensive new discoveries, which appears unlikely, California cannot and will not be able to supply the demand by primary production.

This condition is the same as the one that developed in Pennsylvania many years ago and that led to the extensive development of secondary recovery methods of operation in that area. Thus the first new development in California water flooding has been the appearance of an economic environment favorable to the application of this method of operation.

To date, active California water flood operators have applied as much east-of-the-Rockies knowledge as is consistent with California conditions. Thus one of the important factors for a successful flood, that of adequate preliminary engineering analysis and subsequent supervision is being actively adhered to. Because of the lack of California pool empirical data, the preliminary engineering work has emphasized in particular, core analysis and laboratory flood pot work. The conditions under which these experiments have to be performed differ markedly from those of the eastern pools. Most important in this regard is the fact that the California core samples are generally very soft and friable and those from pools best suited at this time for water flooding contain a relatively low API gravity viscous crude.

This condition has necessitated for one thing the development of a new laboratory technique to prevent sample disintegration during testing. In view of these circumstances it is perhaps surprising that in general the same trends of results have been observed as those encountered for the eastern pools. Thus 13 to 14 deg API crudes both paraffinic and asphaltic in nature with viscosities as high as 300 or 400 centipoises have been moved successfully in flood pot tests and generally at water/oil throughput ratios comparable to those reported for lighter oils. In most instances, where initial oil saturations would predict it, oil banks were formed and neither sand trouble nor the formation of emulsion has been encountered.

Thus as a second new development it may be stated that a sufficient amount of laboratory work has now been performed to indicate that with satisfactory sand and saturation conditions, viscous, low API gravity oils can be displaced by water from friable California sands, some of which contain argillaceous material. One factor that is particularly important to achieve these results is that a proper water be selected for the flooding. In other words then, the idea frequently cited in the eastern literature that approximately 20 centipoises constitutes the upper viscosity limit for successful water flooding has been decisively disproven.

Encouraging as the above results may be, they are admittedly but the first step towards the achievement of a successful flood in the field. Accordingly a number of pilot scale field tests were undertaken by various operators. Some of these have been carried on by now for a sufficient period to give results that are of interpretive value. In general the pilot operations have likewise been successful to the point that at least one of them is currently being extended into a full

The Author

N. van Wingen, vice president, Petroleum Technologists, Inc., Montebello, California, is a graduate of California Institute of Technology and holds a M.S degree from the University of California. His petroleum experience extends over 19 years and ranges from roustabout to chief evaluation engineer with Richfield Oil Corporation. From 1947-49 he was professor of petroleum engineering, University of Oklahoma. He has been active in API and AIME work, holding numerous national offices in both organizations, and has contributed extensively to the petroleum literature. He is a member of the Society of the Sigma Xi, Pi Epsilon Tau, AIME, and is a licensed professional petroleum engineer.

[1] "Current Concepts of Secondary Recovery and Their Application to California Reservoirs," API Drilling and Production Practice 1946.

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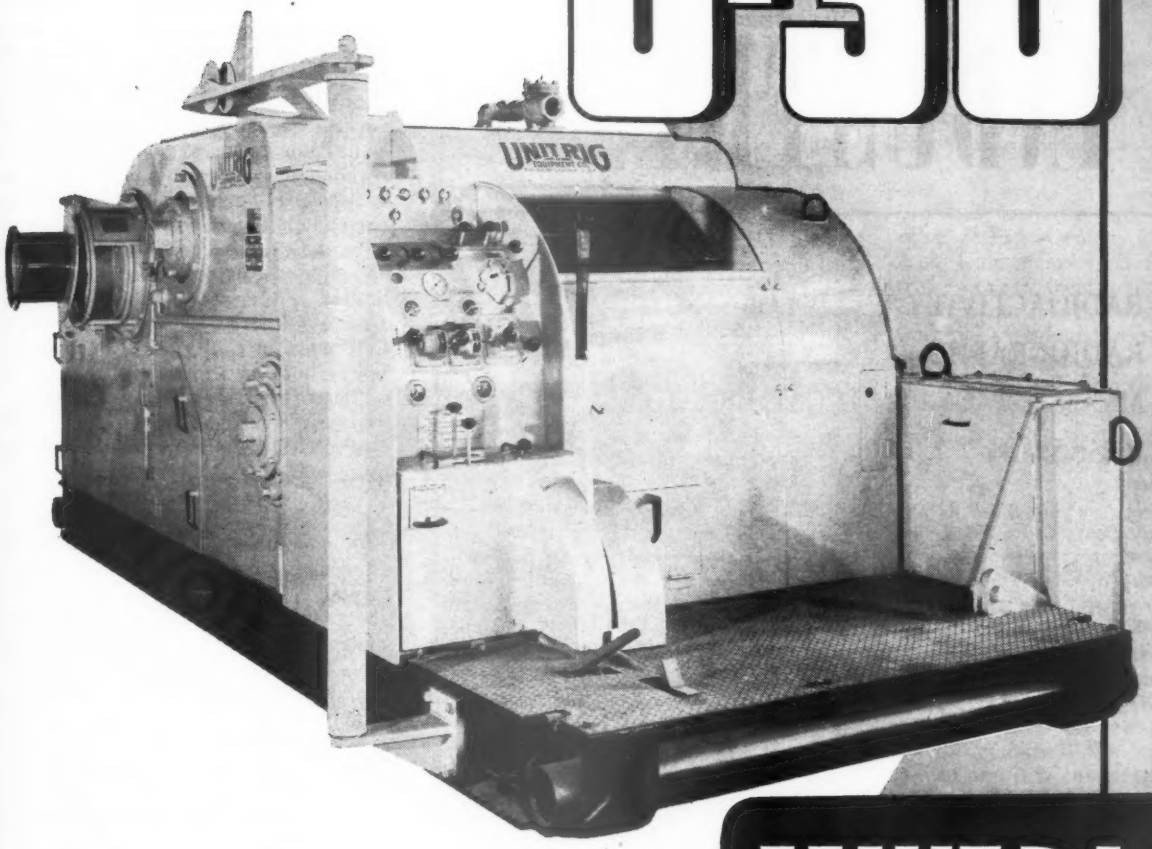

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Water Flooding

scale flood. The third new development is then the successful completion of field pilot tests in relatively low API gravity high viscosity crude areas.

The fourth new development concerns the considerable amount of laboratory as well as field work that has been done in California with non-ionic surface tension reducing agents. This work has been encouraging in that injectivity indices as well as oil production rates were generally found to be increased even for the asphaltic base crudes as encountered on the West Coast. More work needs to be done before generalized conclusions can be drawn, but the future looks hopeful provided adequate cooperation can be established, as between the manufacturers of these materials and the petroleum industry, to develop compounds best suited for the California type crudes.

Much information, some of it controversial, has appeared in the literature of late pertaining to the effectiveness of carbonated water as an oil displacing agent. As the originators of this process portend that it is not so well adaptable to asphaltic base crude as to paraffinic oil, its application in California may be limited. No work has as yet been done actually either to prove or disprove the California possibilities. Even though a few laboratory tests with which the writer is familiar showed some increased recovery, the number of tests is totally inadequate to be even generally indicative.

Conclusion

In conclusion, it can be stated that after having conducted extensive laboratory and pilot plant work, California is about to join the ranks of the states where water flooding is being practiced on a commercial scale. How extensive the secondary work will be will depend largely on the future relation between primary production and demand and the price of crude oil. Furthermore in California perhaps to a greater extent than in other states the resourcefulness of management and their willingness to conduct the extensive engineering and laboratory work necessary prior to the instigation of a field flood is of the utmost importance if success is to be attained. ★ ★ ★

☆ ☆ ☆

This Dangerous Motor Age?

In 1909, the peak year for travel by horsepower, there were some 26 million horses and mules at work, traveling 13 billion miles annually. Thus Dobbin averaged 500 miles per year compared to today's motor vehicle which clocks approximately 9,800 miles each year. In 1909, there were 3,850 persons killed in accidents involving horses and horsedrawn vehicles—30 for every 100 million horsedrawn miles. The current fatality rate for gasoline-powered vehicles is seven deaths for each 100 million miles traveled. And some people call the gasoline age dangerous!

OIL FINDING†

FRANK A. MORGAN

Frank A. Morgan, 1951 president, American Association of Petroleum Geologists, and vice president and manager of exploration, Richfield Oil Corporation, Los Angeles, California.

QUITE a number of years ago when I was a boy in the town of Sonora in the Mother Lode mining district of Northern California we lived on a hill and the streets of the town were covered with crushed rock that had been hauled from the creek bottoms and the mining dumps in and immediately around the town. We had much rainfall at Sonora and after every storm the people of the town would carefully search the freshly washed streets for gold. We found lots of it, sometimes in specimen sheets or splinters, sometimes as colors shot through pieces of quartz and sometimes as well rounded nuggets. On one occasion one of my grammar school pals picked up a nugget half the size of a door knob.

A few years later at the University of California I was able to appreciate particularly the wise words of Dean Frank H. Probert of the mining school when he stated in his characteristic sage manner, "The ore body of tomorrow is the mining dump of today."

Of course he did not mean that as literally as indicated by our industrious prospecting of the Sonora streets, but he did mean that the mining industry with its geologists would develop ore tomorrow in those places that in the past had been overlooked.

No doubt Dean Probert's words were wise and true, but then somebody in Washington decided that we probably did not need gold any more or perhaps it was believed that hard rock geology and gold mining were just too much work as compared with the running of printing presses.

At any rate the gold mining of the Mother Lode is all through, the mines are closed, their timbers are rotting underground and the mills are disintegrating. This leads to the general feeling that the gold is all gone. Of course this is not true, the problem being simply one of hard work, harder than before, and economics. The art of patience and hard work and the science of economics have deteriorated considerably in the United States during the last two decades. This trend is of course one which was not contemplated or even understood by that great citizen Dean Probert, when he hammered home to his students that basic law, "The ore body of tomorrow is the mining dump of today."

I am sure you people have already recognized this little historic sketch as distantly related to the oil industry and the problems of the geologist in petroleum exploration.

Those thoughtful geologists who have given study to all of the facets that can possibly have a bearing on the undiscovered reserve of oil have had to counter with those who are attempting to lay down the rules, who give little thought to the nature of the job, the importance of the results, or the corresponding responsibility; who do little toward improving the economics that would make the job run more smoothly and who at the first turn start searching for some easy substitute for oil that would eliminate the incentive, the risk, the competition, and make the work generally softer as in the running of the printing presses.

The American Association of Petroleum Geologists is a scientific organization that is strictly non-political. If some of these statements sound like politics, they are not so intended. It is just not possible to discuss adequately oil finding in the United States without mentioning the federal government which is exploring for oil, drilling for oil, determining leasing policies, fixing land titles, promoting synthetic substitutes to compete with oil, and maintaining economic and other controls upon its competitors in private industry, which so vitally affect the exploration effort.

This week marks the end of an administrative year for the elected officers of the American Association of Petroleum Geologists. In my case it has been a rare opportunity to work with so many geologists, to visit the members of more than 30 geological societies on two continents, in four countries. I have been impressed that geologists as a group all seem to be the same kind of people—scientists, sound thinkers, hard workers, constructive leaders, loyal Americans—in many respects with a pioneer spirit not dissimilar from those people who used to search for gold in the Mother Lode.

The panorama that I have gained, in spite of the unfavorable cross currents, lends much encouragement in contemplating the future of the earth sciences and particularly the future of oil exploration, the future of our country, and the future of the free countries of the world.

It is obvious that the science of geology has more to work with than any other science. Geology is everywhere we look, from a modest farm window, from a skyscraper, from a train, automobile, or airplane; it is the world itself. As one ambitious geologist stated, "In the absence of interplanetary transportation, my field is limited to the earth."

Unlike geography, we are dealing with many unknowns. As for many of them, the methods of approach and solution remain undetermined, with frequent imponderables that seem beyond the power of imagination. Yet we know that somewhere, however obscure, there are answers to all of our problems, just as there is an answer to the meeting of parallel lines or the dimensions of space. To the geologist a great unknown means simply more work, more research.

The geological science is one of rare objectives and vast rewards for the service of mankind. We are ever moving ahead and it is encouraging that knowledge is the one instrument of production that is not subject to depreciation, obsolescence, or diminishing returns.

Sometimes it seems that advances in the earth sciences are slow, but there is wisdom in the statement of Nathaniel Hawthorne that, "Providence seldom vouchsafes to mortals any more than just that degree of encouragement which suffices to keep them at a full exertion of their powers."

It has also been stated that, "He who would eat the kernel must crack the shell" and thus we as geologists proceed with our job.

We can use dreamers in science if they are constructive. In fact I believe that in this fast moving commercial world there are far too few who have the time or the energy to think.

We have no room for that everlasting segment of industry or science whose thesis is the scare of shortage, or the philosophy of imminent failure. Historically these people have always been wrong in their predictions about oil finding. Their philosophy often has been

†Delivered before the opening session of the annual meeting of the American Association of Petroleum Geologists, Biltmore Hotel, Los Angeles, California, Tuesday, March 25, 1952.

"because I cannot see it or understand it, it cannot be." This would mean that the problems of the infinite cannot be solved and I presume that to many people 10 years ago it would have meant that there could not be any such thing as an atomic bomb, or that the sonic barrier was really a barrier not to be exceeded by man, or that there was no oil in the Cuyama Valley of California or the Spraberry formation of West Texas.

The prime object of the American Association of Petroleum Geologists as stated in its constitution is "to promote the science of geology, especially as it relates to petroleum and natural gas." The constitution then goes on to state that the further objectives are "to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and the technology of petroleum and natural gas."

Most of those statements, to me, mean *oil finding* as there is no force that contributes more to the science of geology and to the technology of petroleum and natural gas than the business of oil finding. Incidentally I like the term *oil finding* better than the term *oil exploration* as we do find oil and we are going to continue to find it. We cannot afford not to.

It has been estimated that approximately 2/3 of the 9000 members of this association are directly engaged in the business of oil and gas exploration and development or are in the federal and state surveys which lend so much support to the exploration effort. Most of the remainder are geology students or are in the teaching profession, led and inspired by those eminent geologists on college and university staffs whom we know so well. These leaders in science and geological thought are in reality the heads of our great family. They are the people who turn out the embryo geologists, most of whom become employed in oil finding.

So it seems that the object of this Association is really to find oil and the search for oil that does so much to promote the science of geology is really the thing which makes this Association possible. It is an endless circle, well balanced, kept vibrant and moving and growing because of results. When production fails no amount of synthetic planning will keep it alive unless the planning be for the return of production.

Active application of the science of geology in a well balanced program of oil finding is scarcely 40 years of age.

We have had one or two occasions in the past when we have been inclined to live on our fat near the peak of overproduction cycles. On such occasions geological and geophysical departments were extensively curtailed, men were discouraged from taking petroleum geology in colleges, jobs disappeared.

Following each case there appeared an inordinate discovery lag, resulting no doubt from the loss in momentum and manpower, and in the failure to maintain the upward curve of technologic improvements.

I have seen recent statements to the effect that we are running out of oil and that by 1975 the petroleum geologists will have worked themselves out of a job. Historically the only times the geologists have worked themselves out of a job have been during periods of great overproduction. This will undoubtedly remain true in the future, given the framework of a healthy oil industry and a stimulating economic climate.

The business of running out of oil is an old story and I cannot understand why it is brought up so often by thinking people. I can see less reason why these pessimistic statements should be given weight now than in the many, many times in the past. They have always been wrong for the reason that they have failed to give due weight to enterprise, determination, responsibility, and an ever-increasing technology.

The geologist of course recognizes that oil is becoming progressively harder to find. It's like hunting game in the deep brush after the animals or the birds have been driven from the open prairie. The difficult areas are none the less natural habitats for game. The same can be said with respect to accumulations of oil.

In my opinion the greatest single tool of the exploration geologist in the future will be access to a more liberal use of the drill for the development of geological information to build up the science of subsurface geology which with insufficient data in the past has been responsible for the finding of many oil fields. I mean by that, a recognition of the need for more extensive geological survey drilling by geologists, the geologists' selling of the idea to management, and the geologists having access to as much of this type of work as is considered necessary for integration with geophysical work and other exploration operations.

With drilling costs having already reached a new peak this principle of course means a new and important concept with respect to exploration costs.

So long as fuel oil is selling for less than bottled drinking water in most parts of the country and so long as synthetic liquid fuels are so much more costly than petroleum products, I do not believe we will soon give up looking for oil in the ground because of economics. Fuel oil is hard to duplicate except through the use of geologists looking for more fuel oil. The same is true with respect to other elements of the mineral kingdom.

Of course I am sure most of us will agree that some day the demand for petroleum products in the United States, and in the entire world in fact, will increase to a volume beyond all possibility of being supplied from oil field discoveries, but with a healthy oil industry I would not consider such a failure a menace to our national strength or to the world.

Oil exploration and development in the future will undoubtedly involve new techniques. Some of these are now known but have not been extensively tried. Others will emerge from necessity, planned research or just plain evolution and accident. Thus it has been from decade to decade in the past. It is no more difficult to predict a future in oil exploration now and what to do about it and how to do it than it was in the early 1920's. The job is just bigger now—in volume and—in responsibility.

I feel that I can speak with some authority on this subject remembering the experts in 1920 when I was finishing my college work, who could not see anything new in exploration technology in sight, who had a very dim view of the future for oil geologists and of this state's ability to find and produce more oil. California's production was then 270,00 bbl per day. Needless to say, now, after 31 years the California production is 1,000,000 bbl per day and we have produced about 8 billion barrels in the meantime.

The great Spraberry trend of West Texas is a good example of something new from a geological and engineering standpoint. Recognized as an important oil accumulation in 1949 this trend has been estimated to contain one billion barrels of oil.

The technology of development of the Spraberry presents new problems in relation to conservation, in maximum recovery, and in the interest of a hard pressed operating economy. The character of the reservoir and the cause of the fracturing present new factors with which we as geologists have had little experience.

This is important as here is a major oil accumulation and here are new conditions. It's not much different from the problem of feeling out the anticlinal theory in the early part of the century or the sand pinch-outs of the 1920's, or the separation of water from gas and oil at the crest of the Ventura Avenue dome in 1920 when the future of that field was regarded with skepticism by so many. Incidentally the technique of exploring and developing this great field at Ventura was finally worked out by geologists and petroleum engineers and with a past production of 421,000,000 bbl, it is now producing 72,000 bbl per day.

The Spraberry problem of today is important because it is big and there must be more like it.

I have always been favorably inclined toward the adage that history repeats itself. Certainly it is important to know history in order to best appraise the present in its relation to the future.

The history of petroleum records a threatened shortage of gasoline at the end of 1913 as a hundred thousand Model T's took the road. Then in 1914 came the discovery of Cushing and we had overproduction.

In 1916 we had shortage again and the director of the U. S. Bureau of Mines predicted petroleum exhaustion by 1943 provided we produced no more than 300,000,000 bbl per year. Here it is

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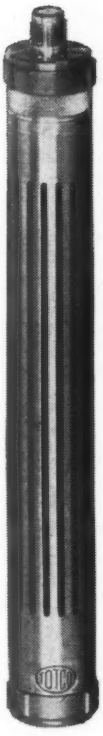

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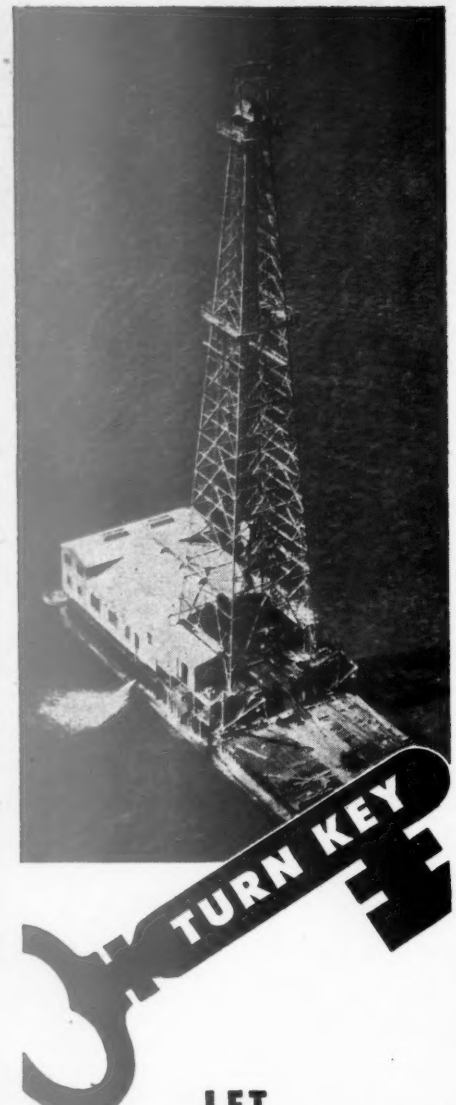

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With our entry into the first world war in 1917 there was fear of a world oil shortage, followed by gasless Sundays and pressure in Congress to restore the 6,500,000 acres withdrawn from the public domain to development. In fact the condition was so serious during World War I that the government was considering taking oil from the Naval Petroleum Reserves. (That must have been serious).

The pressure was relieved without the need for any important action in Washington; in fact, the government agencies became so busy that the price of oil was permitted to increase following supply and demand; then the great Ranger field was discovered in 1918.

A year later in 1919 we had shortage again and the Director of the U. S. Bureau of Mines stated, "In meeting the world's needs . . . the oil from the United States will continue to occupy a less and less dominant position, because within the next two to five years the oil fields of this country will reach their maximum production, and from that time on we will face an ever-increasing decline. We thus see domestic oil fields unable to meet our home demands under present methods of utilization and manufacture. This startling fact cannot be ignored." In 1920 the U. S. Geological Survey estimated only 7 billion barrels of oil left in the United States and Alaska. (That's only 3½ years of production at the present rate). The Survey then stated, "We must depend more and more on oil from other sources or get along with less oil. Our children will doubtless do both."

The scare of shortage began to ease in 1921 and 1922 after Mid-Continent crude reached $3.50 a barrel and Burkburnett, Mexia, Burbank, El Dorado, and the great Los Angeles Basin fields were discovered.

In spite of these discoveries David White, chief geologist of the U. S. Geological Survey in 1922 predicted an early peak of the output of the United States following which "relief must come from other foreign fields and from production by distillation from shale oil, on whose adequacy and on whose yet undetermined cost we may be obliged to rely." (That was in 1922. Does it sound like 1952?)

At this same time in 1922 a committee of AAPG members and representatives of the U. S. Geological Survey estimated the United States reserves of recoverable oil at 9 billion barrels or a 20-year supply.

A bright light shone about that time when Sir John Cadman of the Anglo-Persian Oil Company stated, "Two-thirds of the earth's rock surface is of sufficient age to yield oil. Compared with the places where oil might be found as exploration continues, the work thus far done represents hardly a scratch.'

In late 1923 and 1924 came many new oil field discoveries in the United States and great overproduction, low prices, and the first discussions of proration and conservation.

There were many more ups and downs of production in the 20's and 30's with various types of controls and attempted controls leading up to the problems of World War No. 2 which were highlighted by the thesis of Secretary of the Interior and Petroleum Administrator Ickes that, "We're running out of oil."

The situation was complicated by the war, but in spite of the Canol project and failure to do much about the Naval Petroleum Reserves, we did supply 7 billion barrels of oil for the United States and its allies during the war and we never failed to deliver the products when and where needed. In 1945 the United States oil industry supplied the fighting forces with 35,000,000 gal of gasoline per day. The Pacific fleet was supplied with 630,000,000 gal of fuel oil in 7 weeks.

Fortunately it was then possible to maintain exploration at a rate sufficient to hold the line in proved reserves.

The remainder of the history since World War 2 is well known to all of us. It is highlighted by a steadily increasing demand for oil and an adequate discovery rate. Discoveries, however, have constantly been threatened by shortages of those things so necessary, things so simple, so fundamental—a healthy economy, adequate scientific manpower, and adequate materials.

Thus we witness the events of history that are so similar to the happenings of today. All of the momentous events that appear on the record were influenced deeply by the actions of men. Big men with the aid of science have maintained an increasing oil and gas production and discovery in spite of those who said it could not be done.

Shakespeare's MacBeth strikes a close parallel to some parts of this record—"Life's but a walking shadow, a poor player that struts and frets his hour upon the stage and then is heard no more. It is a tale told by an idiot, full of sound and fury, signifying nothing."

In reviewing all of the pessimistic forecasts and attempted controls, many have been wrong, many have failed, few contributed to getting the job done. The great balancing effect has been the result of the simple rules of private initiative with an occasional assist from the law of supply and demand.

We cannot plan the oil field discoveries for 1952 or 1953, otherwise none of us competitors could afford to be in this room today. But in our science as contrasted with the sciences of politics and planned economy we do have the advantage of knowing that great undiscovered oil reserves inevitably exist, that our technology of oil finding works and that it will unquestionably continue to advance as it has in the past.

Science and technology never die and unlike the many actors who have crossed the stage it cannot be said that geologists and their works will be heard no more. In contemplating the application of resourcefulness to the boundless realm of knowledge and science it must be concluded that "it is earlier than we think."

* * *

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3. The drill collar's hard heat-treated surface that reduces gripping efficiency.

4. The relatively low drill string weight available for wedging the slips into the bowl.

Baash-Ross Drill Collar Slips showing extensions that provide seat for a Baash-Ross Safety Clamp

. . . And *Every* Drill Collar from 3" to 8¼" can have this vital protection!

That's why safety-minded operators throughout the world have adopted Baash-Ross Drill Collar Slips as "must have" rig equipment, because these Slips are *specially designed* to overcome the risks of supporting a drill string in the rotary table. In contrast to the normal fixed-curvature design of rotary slips, the unique multi-segment design of Baash-Ross Drill Collar Slips permits them to w-r-a-p around the drill collar like a chain tong. They take a full slip-proof grip whether the drill collar is new or worn, round or out-of-round. *And they automatically compensate for as much as 1½" change in drill collar diameter—more than ample for modern drilling operations.*

For example, note in the table how a Baash-Ross Drill Collar Slip that fits a 7" diameter drill collar will also fit *any* diameter down to 5½". Adjustment for wear is automatic and continuous throughout the working range!

This means that Baash-Ross Drill Collar Slips automatically take a *full* grip on any drill collar within their range—a grip that gives adequate support to compensate for the continuous wear which changes drill collar diameters . . . for the hard heat-treated surface . . . and for the lack of drill string weight.

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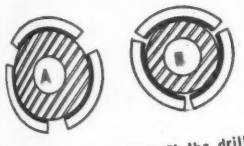
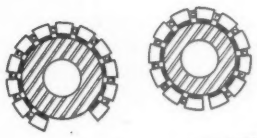
The "Why" of Baash-Ross Drill Collar Slips



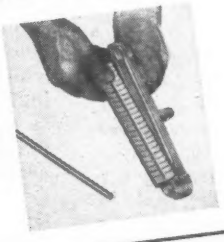
ORDINARY SLIPS that fit the drill collar when new (A) are unable to adjust themselves to smaller diameters as the drill collar wears away. Result, grip becomes less and less adequate (B) and risk of a costly fishing job constantly greater.



BAASH-ROSS DRILL COLLAR SLIPS consist of many narrow slip segments flexibly linked together. Result—they w-r-a-p around the drill collar and always take the same full grip whether drill collar is new or worn, round or out-of-round.

LINERS ARE EASILY RENEWED

To insure long life, minimum maintenance and maximum gripping efficiency at all times, the liners in Baash-Ross Drill Collar Slips can be readily renewed by simply pulling a stainless steel pin, sliding out the worn liner, inserting a new liner and replacing the pin. It's simple, quick and inexpensive!



Sizes and Operating Ranges of Baash-Ross Drill Collar Slips

SIZE	Operating Range From	To
A	3"	4½"
B	3¾"	5¼"
C	4¼"	5¾"
D	5½"	7"
E	6¾"	8¼"

FOR DOUBLE SAFETY

When *double* protection is desired, note that Baash-Ross Drill Collar Slips have extensions above the gripping area to provide seat for a Baash-Ross Safety Clamp—the clamp that puts a non-slip, *yet removable*, "stop shoulder" on *any* drill collar to compensate for the hazards of flush design when supporting the collar in the table. For complete details see your nearest Baash-Ross representative—or write direct!

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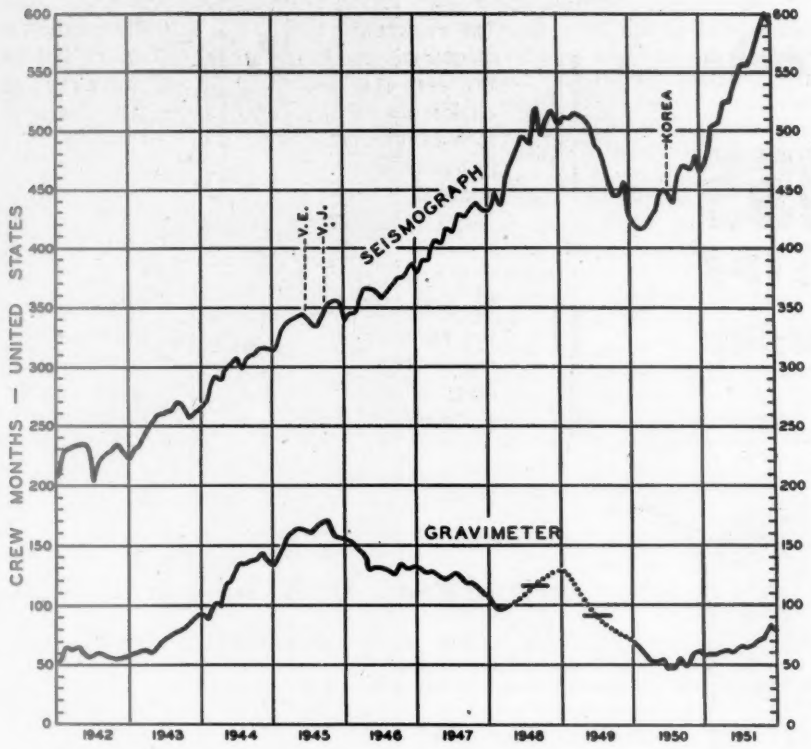

FIG. 1. Monthly variation in seismograph and gravimeter crew-months in the United States.

Geophysical Activity†

Seismograph work increased 20 per cent in 1951; gravity work rose 12 per cent

E. A. ECKHARDT*

UNPRECEDENTED is the word that most aptly describes the expansion of geophysical activity that took place during 1951. The seismograph work done everywhere by the oil industry during the year required the full time services of 791 crews, an increase of 134 crews or 20.4 per cent over 1950. Gravity work was also done in substantially greater volume during 1951, requiring the full time services of 123 crews, an increase of 13 or approximately 12.2 per cent over 1950.

The number of crews reported as operating in the U. S. is plotted on a month-by-month basis for both seismograph and gravity in Fig. 1. The chart covers a period of 10 years and shows vividly that at no time during this period, and in fact during any other, did the number of seismograph parties rise at so rapid a rate. The increase in gravity operations was less pronounced, but strongly upward. The chart shows at the peak in November 600 seismograph parties working in the U. S. The slight drop in December is of no significance. Such drops have occurred at the same season in practically every year and are of a seasonal character. If during all of 1952 seismograph work were done at the year-end rate of 1951, without further increase, the 1952 rate would exceed the average 1951 rate by approximately 10 per cent. Actually it is to be anticipated that the increase will be moderately greater than this.

In accomplishing the increase that occurred last year, the geophysicists have accomplished something of a miracle. Their number is not capable of expansion at will. A geophysicist is the product of training and experience. The acquisition of both takes time. The number of technically trained men that became available from the colleges and universities last year was far short of the demand for them by all industry, and the shortage had its full effect in limiting additions to the geophysical forces. The registration of the students now in the schools make it clear that in the face of rising demand, the supply of graduates in the sciences and engineering will be decreasing for several years to come. The availability of suitably trained and experienced men is bound to prove a major obstacle in the maintenance and further expansion of geophysical services.

If you will take your hair down with me, you will admit that geophysicists, on the average, are currently not doing the best possible job. That this is so is not particularly their fault. There just are not enough of them to handle the volume of work there is to do. Most of them have to keep track of more kittens than can be kept neatly tucked away in the basket. One must not be surprised if some kittens go astray.

Although this is a familiar story to most of us who are directly engaged in wrestling with these problems, there is need that it be fully understood also in other quarters. The intelligent expansion of geophysical services requires long range planning so that there is time to train men and give them the experience they will need to handle their jobs successfully. It is also important that each trained and experienced geophysicist be assigned in a manner to make the most effective use of his training and experience. There are not enough of them to go around; none of them should be wasted.

What has just been said about the manpower situation in our business when viewed against the background of our rearmament economy deserves the most careful consideration of our draft boards and the military authorities. Unless they, as well as industry, recognize that the pool of technically trained men is well below the needs of the country and temper their drafts from the pool accordingly, the vital defense effort will suffer. In the national interest they, too, have the obligation to make the best possible use of their technical training and experience when such men are called to active military service. Unless this obligation is recognized and made an integral part of selection policy, an already critical situation could easily become disastrous. It is reassuring to note that reasonable progress in this direction is being made. At best, however, the state of affairs can only be described as spotty.

Much has been heard in recent years from Gobble-de-gook Center about equality of sacrifice or the equal distribution of the burden. It is an idea to which all of us can readily agree in principle. From some of its propounders one gets the impression that this is of first importance, a requirement to which all

†Report of the Committee on Geophysical Activity of the Society of Exploration Geophysicists. The members of this committee are A. A. Brant, Herbert Hoover, Jr., D. C. Skeels and E. A. Eckhardt, Chairman. Presented at the Los Angeles meeting of the Society, March 24, 1952.

*Gulf Research and Development Company, Pittsburgh, Pennsylvania.

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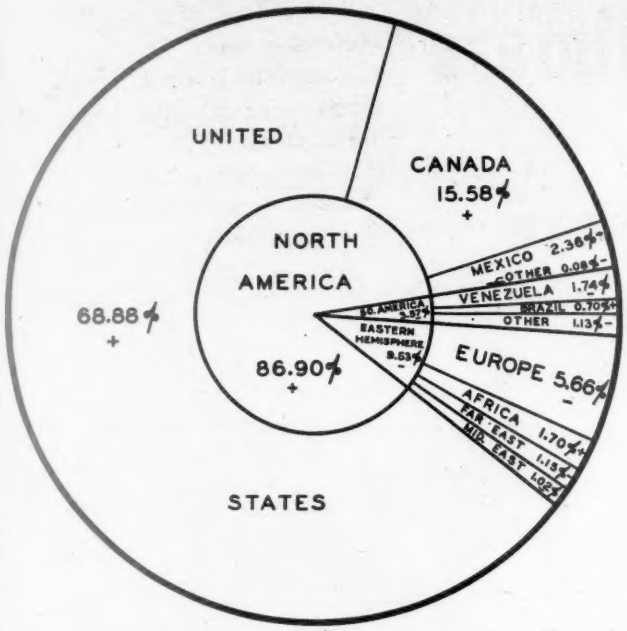

FIG. 2. World distribution of seismograph operations in 1951.

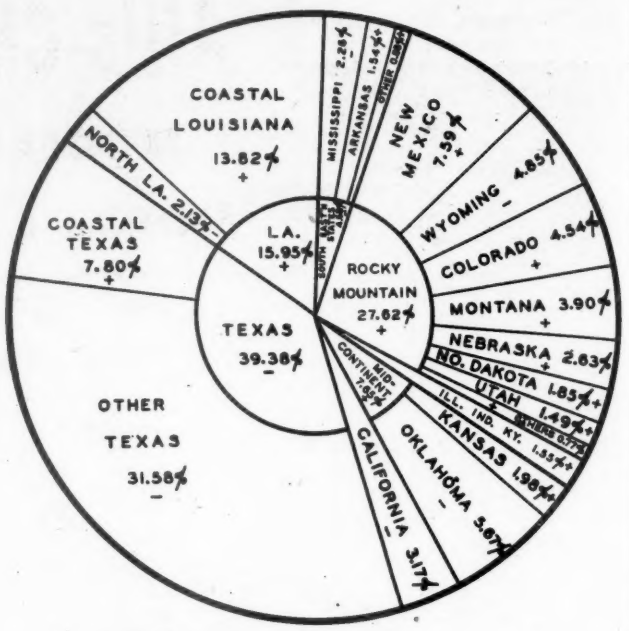

FIG. 3. Distribution of 1951 seismograph operations in the United States.

others must be subordinate. In truth our greatest need is to win the struggle in which we are engaged. In sheer weight of manpower we are outnumbered, and we can hope to win only by superior use of our technology and technologists. Should we take technologists out of technology in order that equality of sacrifice may be more completely achieved? A complementary question is, "Should we permit anything that will make the winning of the struggle more uncertain, lengthen its duration, and increase its cost?" An intelligent answer to the second question automatically provides an answer to the first. This answer may not be socially palatable, but we had better heed it and thereby improve the chances of saving our skins.

The question of geophysical personnel has been dealt with at such length because it is critical in determining whether the need for geophysical service by the oil industry can be met in quality and quantity. We need more well-trained and experienced men for the operations in being. We will need still more if we are to expand the operation to meet the apparent demand.

North America contributed the major component to the 20.4 per cent increase in the world total of seismograph operations during 1951, the actual increase being 1519 crew-months for a 1951 total of 8248. For Canada the increase was 286 and for Mexico 90. Percentage-wise the increase was greatest for Mexico (66.7 per cent). Canada was next with an increase of 23.9 per cent and that for the U. S. was 21.8 per cent or somewhat, but not markedly, above the average world increase. The trend away from the U. S. noted in the report for 1950 was clearly reversed last year. There was a less than average increase in the Eastern Hemisphere and a small decrease in volume in South America. The greatest percentage increase occurred in Africa, where activity more than doubled, and the greatest decrease, both numerically and in per cent, took place in the Far East. This decrease is probably closely related to the unsettled political situation in that area.

The world distribution of seismograph operations in 1951 is shown in Fig. 2. The pie is larger than for the preceding year but no major change in the size of the slices is apparent. Here and in the other charts the plus and minus signs indicate whether any given slice is larger or smaller compared to 1950.

In the U. S. the 1951 increase in seismograph operations amounted to 1172 crew-months. The Rocky Mountain States, Louisiana, and Texas accounted for nearly all of it, and in the order named, the increases being 570, 303, and 241 crew-months and 46, 41, and 10 per cent, respectively. The geographic distribution of seismograph operations in the U. S. in 1951 is shown in Fig. 3. Texas retains its commanding lead, but by a reduced margin. As will be noted, Texas, the Rocky Mountain States and Louisiana accounted for approximately 83 per cent of the seismograph work done in the U. S. last year. Among the Rocky Mountain states activity was most concentrated in New Mexico, Wyoming, Colorado, and Montana, in that order, and these states were the seat of over 75 per cent of the activity of this area.

Gravity operations the world over rose moderately during 1951 from a level of 1320 crew-months in 1950 to a total of 1481. As will be seen by reference to Fig. 4, over half of such work last year was done in the U. S., which accounted for practically the entire world increase. The downward trend in evidence in U. S. operations for several years back was definitely reversed and at year end they were substantially at the highest level of the year. In Canada gravity work was done in practically the same volume as the year before and therefore its contribution to the world total declined. Considerable gravity work was done in Mexico last year, and it more than doubled its percentage share of the world effort. As was true also in seismograph operations, the greatest decline in gravity work was experienced in the Far East. Other shifts are readily apparent from the chart.

The geographic distribution of gravity operations in the U. S. in 1951 is shown graphically in Fig. 5. Out of a total of 802 crew-months reported for the country, Texas, with 36.7 per cent, continued to hold the No. 1 spot. There was a relatively pronounced gain in Louisiana to a level about equal to that of the Rocky Mountain states. Between them these three areas accounted for over 84 per cent of domestic gravity operations last year. The greatest gain occurred in Louisiana, more particularly in coastal Louisiana, and the greatest relative loss was recorded for Mississippi.

Again it is impossible to make a report on magnetometer operations on a basis comparable with the other activities. Data received do not differentiate between ground party and aeromagnetic crew-months, and since ground parties may use a variable number of instruments, the meaning of ground crew-months is correspondingly indefinite. As aeromagnetic and ground parties involve cost ratios of the order of 10 to 1 and data production in ratios of the order of 100 to 1, the problem of keeping track

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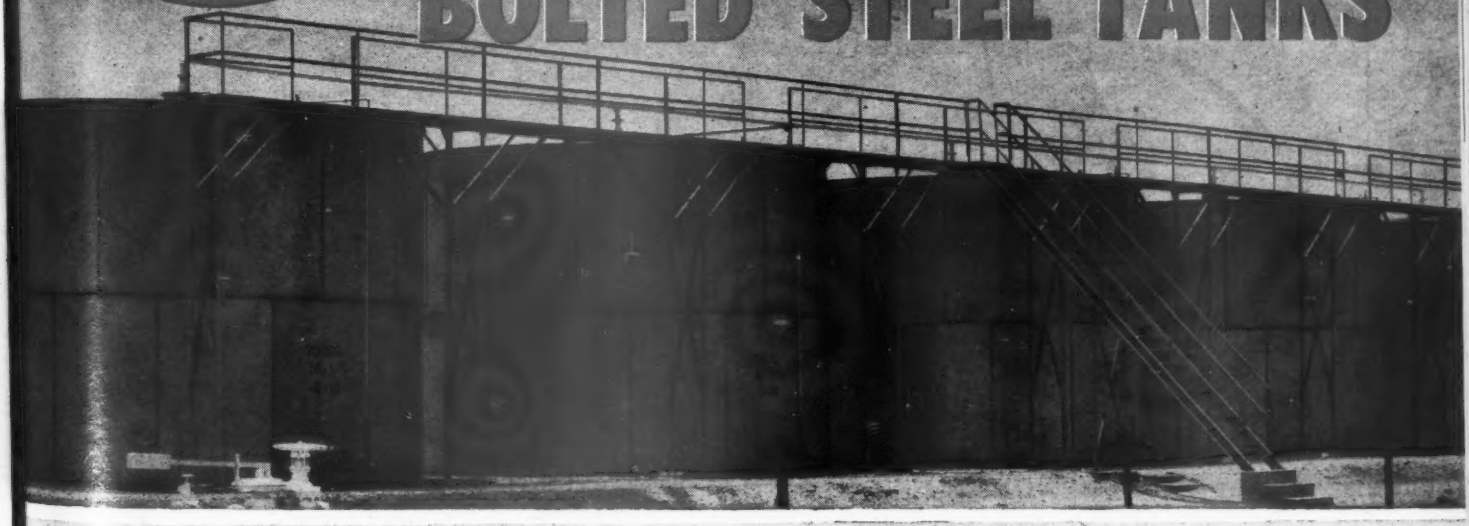

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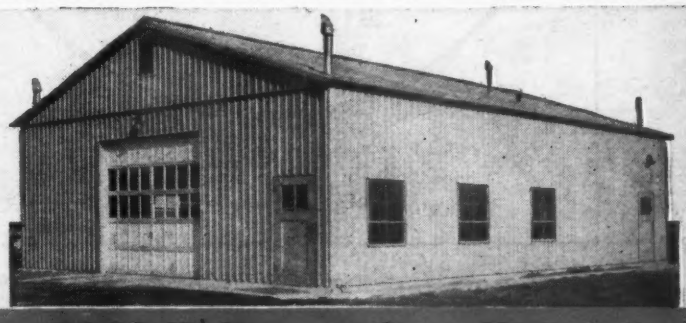

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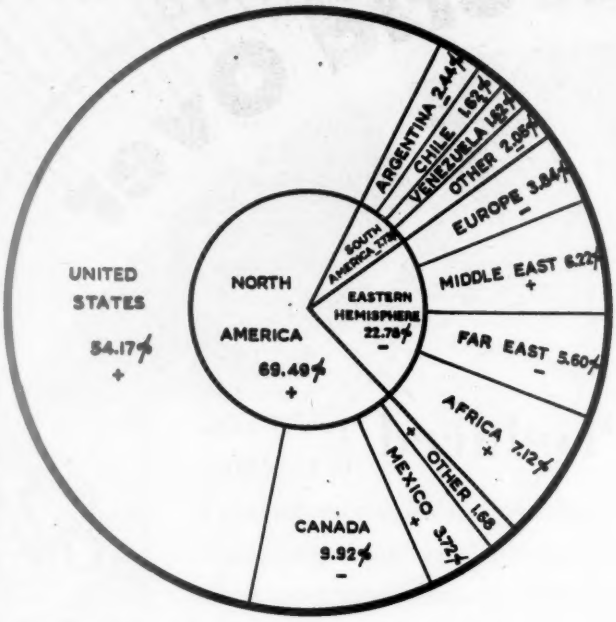


FIG. 4. World distribution of gravimeter operations in 1951.

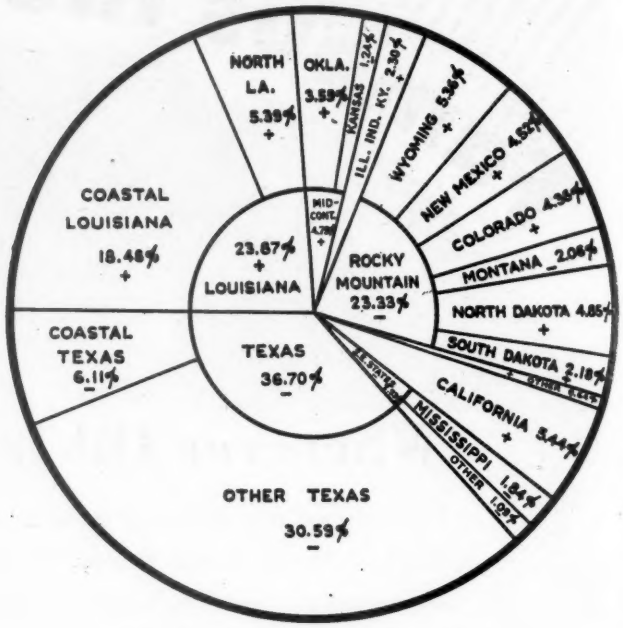


FIG. 5. Distribution of 1951 gravimeter operations in the United States.

of even trends becomes somewhat complicated. To date your committee has had no success in providing you good data for magnetometer operations. It is probably true, however, that much more magnetometer work was done by and for the oil industry last year in comparison to those immediately preceding.

For its geophysical operations in 1951 the oil industry probably spent not less than $300,000,000 and possibly as much as $350,000,000. The bill for 1951 is greater in part because of substantially greater volume and in appreciable part because of greater unit costs.

Preliminary figures for 1951 indicate that U. S. production of crude oil for the year reached an all-time high of 2,242,698,000 bbl, exceeding the previous peak of 1948 by 10.6 per cent. As a result of 1951 operations there was a net increase of 1.416 bbl in the estimated crude oil reserves of the country. The oil produced during the year was replaced by new discoveries and an increment of roughly 1.4 billion barrels was added to reserves. The discoveries for the year therefore were 3.659 billion barrels approximately. Before 1951 the peak year was 1937. The following comparisons for the two years are of interest, the units being millions of barrels:

	1937	1951
Total discoveries	3342	3629
Production	2042	2213
Net addition to reserves	1300	1416

It is clear that 1951 was an all-time record year for the U. S. oil industry with respect to total discoveries, produc-

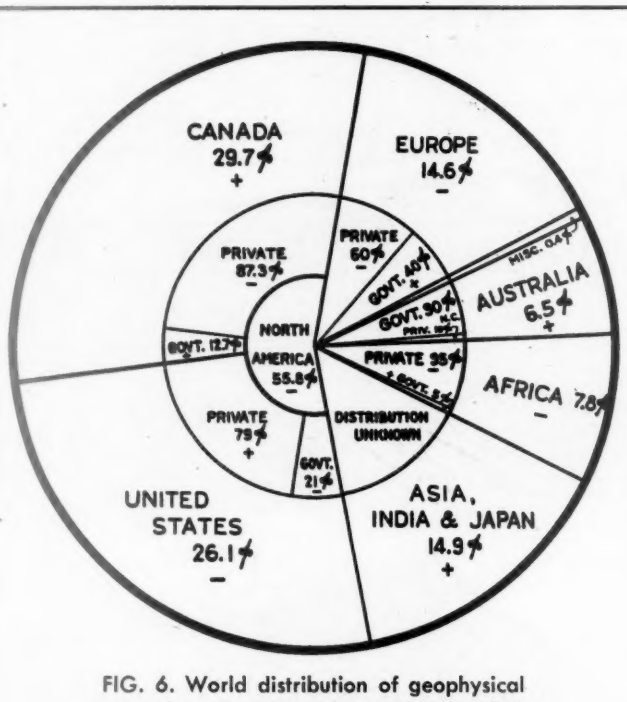


FIG. 6. World distribution of geophysical operations in mining by areas in 1951 on professional man-month basis.

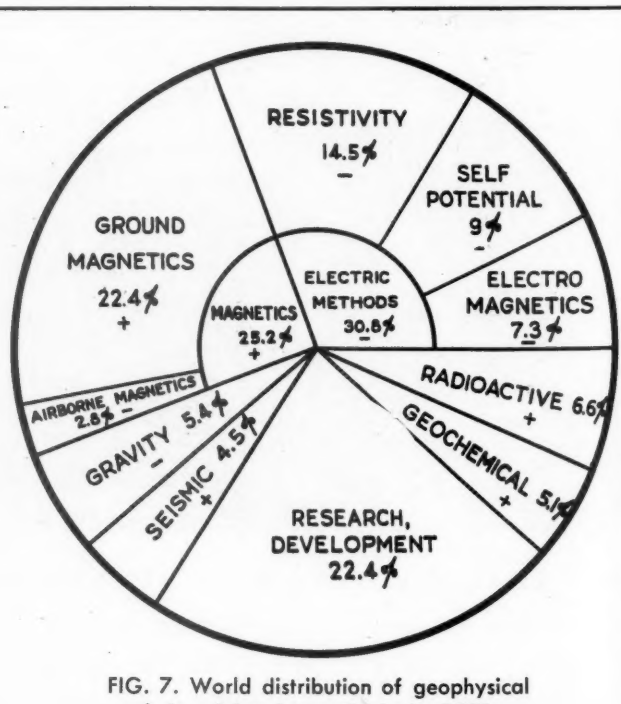


FIG. 7. World distribution of geophysical work in mining by methods in 1951 on on professional man-month basis.

tion, and net addition to reserves. In fact, it appears to have been a record year for the industry in all respects with the notable exception of profits. It is a record to which geophysicists have made important contributions and an achievement in which they can take great pride. We may also derive great satisfaction from the realization that this contribution has been made to a vital component of our national economy, and the anxiety of the nation can be somewhat relieved by the fact that the oil industry met its problems so successfully.[1]

Geophysical Activity in the Mining Industry

Based on the data available for compiling this report, the mining industry spent over $3,500,000 for geophysical operations and research and development in 1951. Dr. Brant, who has been in charge of gathering the mining data, estimates that, as was the case last year, the data cover only about 60 per cent of the actual activity in the industry. One may guess that the total expenditures of the industry for the year for these purposes were in the neighborhood of $6,000,000. The expenditures actually reported to us are about 50 per cent greater than those reported for 1950.

In the data received there were a few obvious discrepancies between the man-months and the dollar costs reported. As this was discovered too late to rectify by further inquiry, the charts were prepared this year in terms of professional man-month units. Although this impairs somewhat the comparability with previous reports, it was about the only thing that could be done. On analyzing the result, one is tempted to conclude that this may prove to be a better one than the dollar basis used in previous years. One advantage is that distortions due to varying costs of similar work in various countries are avoided.

On this professional man-month basis, Fig. 6 shows the geographic distribution of geophysical operations in mining for 1951. The seesaw relationship between Canada and the U. S. perceived in previous reports persists and in 1951 Canada took top rank in both man-months and dollars, with the U. S. in second place. The positions of Europe and Australia remain about the same. Out of Asia there are reports only from India and Japan, and these countries have expanded their activities relatively more than the others reported. In Africa the volume of activity actually decreased as compared to 1950 and the slice of the 1951 pie chart for this area became correspondingly reduced.

The distribution of the 1951 work in mining geophysics between the methods used is shown in Fig. 7 which is also on the professional man-month basis. Ground magnetics and research and development, at 22.4 and 22.3 per cent, respectively, accounted for the largest sectors, although electrical methods as a group represented 30.8 per cent of the total. These distributions would not be greatly changed on a dollar basis chart.

The situation is quite different, however, in the case of aeromagnetics. In the man-months chart aeromagnetics occupies a sector of 2.8 per cent. In a dollar chart the sector would cover about 30 per cent. This illustrates the difficulty of presenting a fair picture, a difficulty that is most pronounced in the case of aeromagnetics. Aeromagnetic surveys are usually paid for on the basis of money units per profile mile. It takes about one professional man-month to turn out a map for about 500 profile miles. On the ground the same professional effort will turn out something in the neighborhood of 25 profile miles. In aeromagnetic surveying the professional man is about 20 times as productive as he is in ground surveys. He also spends money faster, as is usual in a mechanized activity. The over-all unit costs are greatly reduced, however. It by no means follows that ground magnetic surveys are rendered obsolete by aeromagnetic techniques. Canada occupied the "No. 1 spot" in both ground and aeromagnetic activity last year.

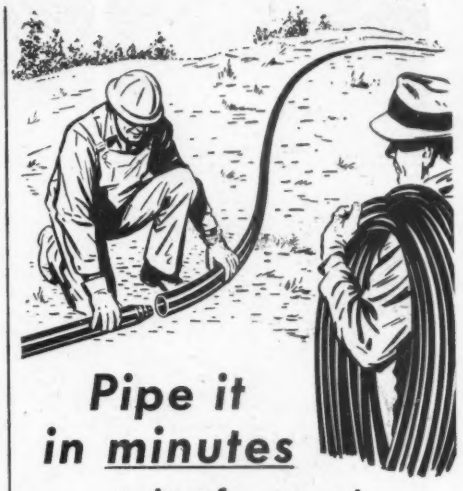
Some things not apparent from the charts deserve mention. Aeromagnetic activity in 1951 was greatest in Canada, the volume in the U. S., Sweden, Finland, and Africa, as reported, being in that order. Canada led also in ground magnetics with such work in the U. S., Africa, India, Australia, and Sweden, being in decreasing order. Gravity work was done in about equal amounts in Canada and the U. S., with Australia, France, and Africa next in that order. In self-potential surveys, the U. S. ranked first, followed by Japan, Africa, India, and Canada in the order named. In resistivity work, the U. S. also held first place, followed by Africa, India, Canada, Japan, and Switzerland. In electromagnetic surveys, Canada was outstandingly first with the U. S., Sweden, and Finland tying for second place. In seismic surveys, Canada was also the leader, by a slight margin, with Switzerland and Japan being in second and third positions, respectively. Most of such work in Japan was related to coal. In radioactivity surveys, the U. S. occupied first place with a commanding lead. Australia was second, Canada third, and India fourth. In geochemistry, the U. S. accounted for more than three quarters of the world activity. Most of the remainder was done about equally in Canada, Australia, Africa, and Japan.

Expenditures for research and development were greatest in the U. S., with Canada a very close second. India was in third place, and Australia, Switzerland, and Africa followed in that order.

Twenty crew-months of work, distributed in an unspecified manner between gravity, seismic, and electric methods were reported from Italy. For these, 20 professional man-months were added to the world total in an arbitrary manner.

* * *

[1]After the compilation of this report had been completed data were received covering work done in Australia. These included 58 crew-months of seismograph and 45 crew-months of gravity work. These additions bring the world total of seismograph crew-months for 1951 up to 9549 and the total for gravity to 1526.



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P 974.3

Part 1 of an Unusually Valuable Report on

Economic Advantages of Unitization†

BRUCE A. LANDIS, JR.,* AND L. E. BROCK*

THERE is no need to attempt to justify the need for and the benefits of the secondary recovery of petroleum. The petroleum literature contains numerous proved examples and one is familiar with individual successful programs.

It is necessary, however, to give in a general way, a statement on the aim of unitization. Many in the unitization phase of the industry regard unitization of an oil or gas reservoir as a method of operation, the effect of which is to assist in producing a greater volume of oil and gas for less money than would be possible were unitization not employed. Do not think that unitization is a cure-all for every production ill. To the author's knowledge none exists. But there is a belief that unitization has become a very effective tool in our drive toward the goal of conservation. Conservation is no more than the most intelligent production and use of our resources. Conservation is the result if waste is eliminated, and unitization is a way to provide for the elimination of waste of oil production, be it above the ground by prevention of gas flaring, or within the reservoir by more efficient recovery of crude and condensate.

Unitization is a method that provides a common ground where all operators of a field can meet to exert more control over the production mechanism used to deplete the field than the sum of their efforts would total if they all acted severally; accordingly, unitization may be defined as the act of combining separately owned tracts and rights in certain lands and leases in a way that will allow orderly development and maximum ultimate production without regard to lease or property lines, but with due regard for the correlative rights of all parties.

A unit operation is the nearest approach we have yet made to the Utopia of oildom, that is, the maximum economical recovery of petroleum hydrocarbons. This higher ultimate recovery is possible because the engineering program best adapted to the particular type reservoir is followed as a matter of course. A unit can be regarded as one large lease encompassing the whole of the productive area. This removes one basis of lessor or other royalty owner complaint that a lease is not being developed as fast as the one next door. The regulation of operations by duly empowered conservation bodies can be held to a minimum, because what may have been defined as waste under competitive primary production becomes an added reserve and a source of increased revenue to a unit.

There are more results to be obtained from unitization. In addition to the economic gain, which has become known to operators who have had experience with units, there is the pride of achievement that comes from being a part of a picture where individuals have found a way to cooperate for their collective betterment without surrendering any portion of the principles of free enterprise to which they are so strongly dedicated. This is, by the way, a critical feature. Free enterprise, especially in the petroleum industry, will be maintained only so long as its proponents continue to demonstrate that it is the best system for national economy. Unitization, properly conducted, is a demonstration by the oil man of his awareness of the public's concern in conservation of petroleum.

Perhaps it would not be amiss here to spell out a hasty summary of the historical background of unitization. Through history many things are better understood, which, upon their face only cause perplexity. Through the history of democracy is understood the necessity for a current and continuing effort to guard freedom. Through the history of unitization can be understood the need for serious consideration of additional unitization efforts.

History

To emphasize at the beginning, unitization is not a new subject. As early as 1916 McMurray and Lewis[1] of the United States Bureau of Mines recognized unit operation as a means for eliminating waste. They thought that unit operation would eliminate waste above ground brought about by gas flaring. Two years later, Gilbert and Pogue[2] in a technical paper stated an opinion that unit operations would increase the ultimate recovery of oil. Between that time and 1924 very few references, if any, are to be found that clearly advanced the idea of unit operation as a way to increase ultimate recovery; but in 1924 Henry L. Doherty, president of H. L. Doherty and Company, fiscal agent for the Cities Service Companies, began a presentation of the strongest arguments for unitization of oil and gas pools that the industry had yet heard.

In August of 1924, Doherty wrote a letter to President Coolidge in which he expressed his fears that the nation's oil supply was rapidly becoming exhausted because of the waste of natural gas and the overproduction of oil. He made a strong appeal to the President for the immediate imposition of strict conservation measures under a system of federal control. It was Doherty's fear that another war was not too remote, and that if war came we would not be prepared to supply the quantities of oil necessary for its successful prosecution.

In early December of that same year Doherty unsuccessfully attempted to present his views before the American Petroleum Institute. Upon being advised of the Board of Directors' refusal to grant him a hearing, he informed them that he would go directly to the public; and in February of 1925, before the Petroleum Division of the American Institute of Mining and Metallurgical Engineers, in New York, Doherty[3] launched a vigorous campaign for federally controlled unit operation of oil fields.

Had Doherty approached the idea of unitization from a voluntary instead of a compulsory viewpoint it is highly probable that he would have met much less opposition and would have been given a much wider audience by the industry itself. His speech provoked many denials of wasteful production methods but hardly a voice was raised against unitization as a method in increasing ultimate oil recovery. It was the threat of federal compulsion and invasion of the industry that led, for the most part, to the hotly voiced opposition to Doherty's views. There were many operators who sensed the merit of unit operations, if only as a way to put a brake on the overproduction that was plaguing the industry.

Space limitations prohibit all but a brief discussion of the evolution of unitization. For those who would like to make a more comprehensive study, strongly recommended is Robert E. Hardwicke's excellent volume, "Anti-Trust Laws et al vs the Unit Operation of Oil or Gas Pools."[4]

Prior to 1931, numerous appraisals of

†Presented before the North Texas Oil and Gas Association, Wichita Falls, Texas, March 29, 1952.

*Unitization section, Stanolind Oil and Gas Company, Tulsa, Oklahoma.

unitization and its effects were made by various petroleum and governmental groups, and a few units were formed. The first rapid growth in unit formation occurred during the middle thirties when so many condensate reservoirs were discovered. It was recognized in the beginning that due to the inherent characteristics of condensate reservoirs many of them should be cycled. This could not be done without violation of property lines, hence many such reservoirs were unitized of necessity.

During World War II, the oil industry again became unitization conscious to a marked degree when operations were subject to considerable Federal control. Materials shortages and huge demands for oil brought home to many operators the need for saving materials by drilling and equipping only those wells necessary for proper depletion and the need for producing more oil from any given reservoir.

The current increased unitization activity began when the entire nation, at the conclusion of the last war, realized the importance of oil to our decisive military victory. The leaders of the industry foresaw:

(1) That tremendous demands were goto occur for oil.

(2) That the most accessible sources of additional reserves were the already discovered and partially depleted fields.

(3) That to recover these additional reserves, secondary recovery programs had to be inaugurated.

(4) That unitization of the various fields was a prerequisite to the adoption of the contemplated secondary recovery programs if they are to be operated at best advantage.

Two outstanding characteristics trend through this whole history of unitization. First, no serious organized opposition to the principle of unitization has ever arisen, and so far as we know, there is none today. Also, the lingering fears expressed many times in the past that units tended to violate federal and state government anti-trust laws because a certain measure of control must be exercised over production, have been proved to be exaggerated and the recent legislation passed by various oil producing states has served to remove doubt in this connection. It is now recognized that a certain measure of control over production is a prerequisite to obtaining higher final recovery.

Great advancements have been made since Doherty first directed his attention to units. But there is today a current lack of knowledge of the present status of unitization on the part of the public especially, and also to a lesser degree on the part of some segments of the industry.

Some knowledge of the present scope of unitization may be had from reports of various petroleum organizations. For instance, the Interstate Oil Compact Commission reports from data compiled in 1948 that there were 160 unitized projects of all kinds operating within the United States. Of these, 31 were situated in the state of Texas, 10 of which were oil fields and 21 gas condensate fields. The average producing life of 147 of these 160 fields before unitization was 9½ years. Two of these fields were unitized 40 years after discovery and 12 within the year of discovery. It is a matter of interest to note that of the remaining 13 fields all were unitized before discovery, one being unitized 14 years before discovery, the other 12 being unitized one to two years before discovery. The most recent data of the Interstate Oil Compact Commission, as yet unpublished, show that approximately a twofold increase in unit operated projects has occurred since 1948.

H. H. Kaveler[5] of Phillips Petroleum Company in a recent speech stated that "the unitization field has been plowed many times." This is true, but in the interest of progress it would be well to turn another furrow or two, and add a few general remarks concerning the economic advantages of unitization. In addition the actual economics of some recently formed units is explored in some detail.

General Economic Advantages

In a general way the following economic advantages are self-evident from the very nature of the unit operation. Flare gas can be utilized in many ways; allowables can be transferred from high gas-oil ratio wells to low gas-oil ratio wells, and a greater ultimate recovery obtained by this selective production. It is possible to store produced gas underground until a market is developed for its sale, and although effecting this storage by controlled gas injection into the reservoir, maintain the reservoir pressure at a point calculated to increase ultimate recovery. It is also possible to reduce operating and development costs and material inventories. The duplication of effort, camps, gas, water and other facility systems, tankage, pipe lines, pump stations, and administrative systems found under competitive producing operations can be almost totally eliminated from unitization.

In addition to the foregoing advantages of reducing physical inventory, development, and operating costs, there is the decided advantage of a common pooling of knowledge. Under the normal unit program a vast fund of experience and oil operation know-how, at insignificant cost, becomes available to every operator. The chances of reaching the soundest decisions are immeasurably increased when every problem is viewed through the eyes of expert practitioners, and a decision is not made until every member of an advisory committee, where each operator is represented, has had an opportunity to study the problem and vote. There are times today, of course, when one must still use trial and error methods to produce a tangible result. But it is surely preferable to confine this method of reaching a conclusion to an expert panel rather than to create the expense of individual trial and error.

Today when contemplating an economic benefit it is well to think of the income tax structure. Units are taxed as entities. The Bureau of Internal Revenue has recognized that a unit is not a partnership, corporation, or association for income tax purposes, thus each individual operator's income is taxed on the same basis as though he were not committed to a unit. In those cases, however, where adjustments of investments are made by the parties to the unit, an income tax question may arise.

Taxation is mentioned only to point out that income tax remains an individual responsibility. Ad valorem and other taxes are generally an item of unit expense, and the unit operator is charged with the responsiblity of seeing to their payment and the administrative details concerning them.

From an economic standpoint a study made about 1930[6] is of considerable interest. It was reported at that time that if the Seminole pool, in Oklahoma, had been unitized instead of produced competitively the saving in pool development costs by elimination of the wells that were not needed to deplete the reservoir would have been $17,000,000, and the saving in operating costs in producing the field to depletion would have amounted to $14,500,000. These estimates were made on primary recovery only and no study was made of secondary recovery of oil. The $31,500,000 which would have been saved was equivalent to 50 per cent of the profits estimated for primary competitive operations. A similar study[7] showed an estimated saving of $51,700,000 for the Santa Fe Springs field, California, had it been unitized instead of competitively produced.

There should be no doubt in the unprejudiced mind that excessive well drilling, as exemplified by these two case histories, has occurred time and time again throughout the oil fields. It is occurring still, and a moment's reflection will indicate that unitization in early field life can prevent this waste of physical equipment and at the same time reduce costs of operation.

Reports of unit performance that are currently being published in the literature show one common trend—higher ultimate recovery and reduced operating costs. It is no longer a matter of conjecture—unit operations with their comparative economic advantage over competitive production operations are here to stay. A wider embracement by the industry, however, and especially the independent grouping of the industry, is necessary to realize the fullest economy.

Economic Advantages of Specific Units

If there is a single fact upon which agreement can be reached it is that oil and gas are by nature migratory and that lease lines upon the earth's surface do not and cannot restrict the movement of oil and gas through an underground reservoir. The conditions of the reservoir rock or the reservoir fluids therein cannot be altered to any degree. The physical characteristics of these

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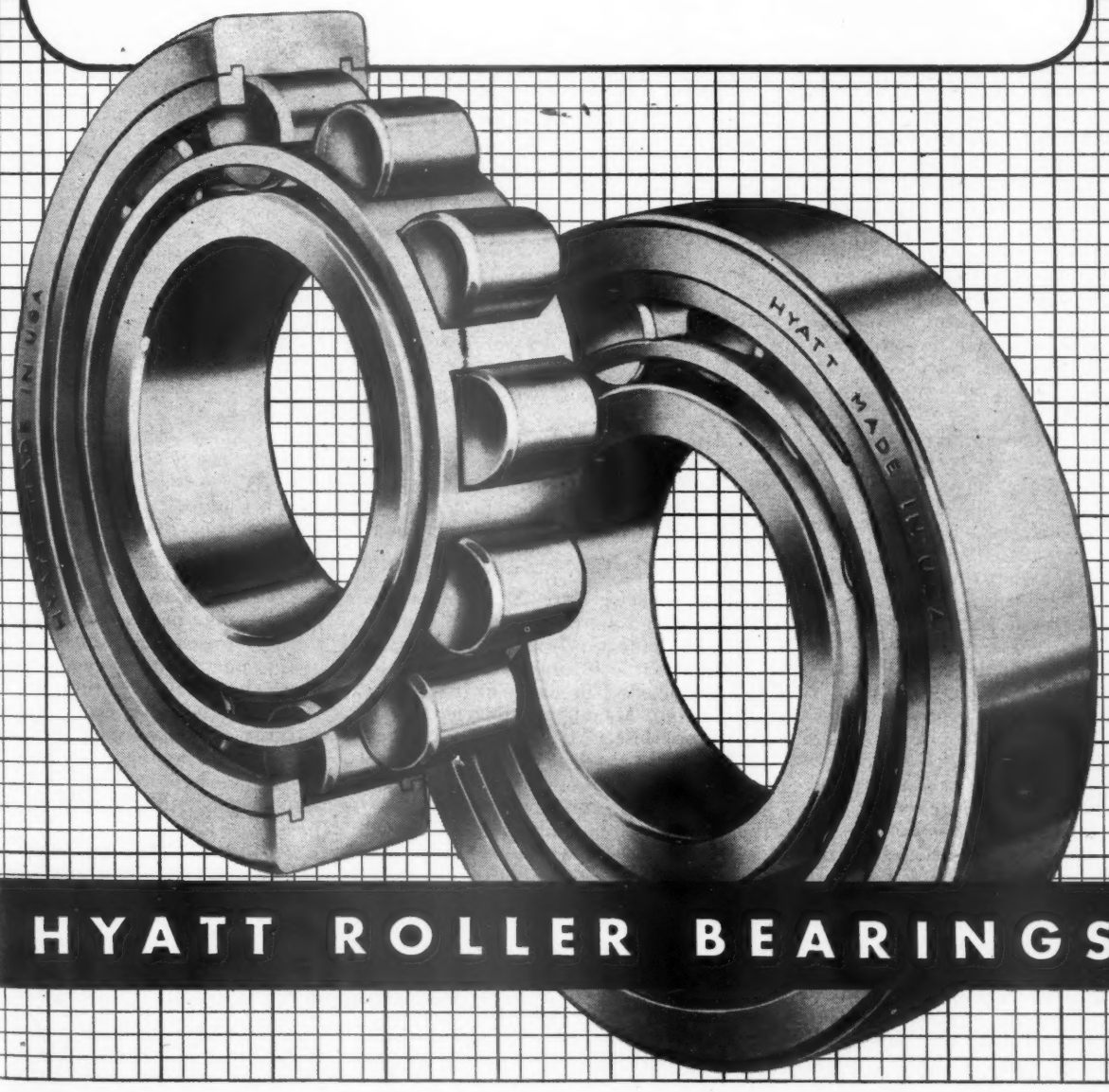

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dictate the manner in which a reservoir must be produced to effect maximum recovery. Through experience and study, methods have been devised of increasing ultimate recovery with pressure maintenance by selectively producing and/or by water or gas injection. The fact that so much oil remains in the ground after competitive operations is proof that still newer and better tools are needed with which to work; and unitized secondary recovery is one of these.

It is within the experience of all to have known of petroleum reservoirs hastily produced to a stage of uneconomical operation with a total recovery of only 10 to 20 per cent of the initial oil in place. There is at least one instance where a field has been depleted a second time in a manner almost identical to that employed the first time. When the Olney field in Wichita Falls' backyard was depleted and ready for abandonment, natural gas was purchased and injected into the reservoir for two years without any withdrawals. Upon subsequent production 69 per cent more oil was recovered. There are many instances where secondary methods have been initiated late in the primary depletion stages with subsequent increased oil recovery, of which the Bradford field of Pennsylvania is representative. Both of these are within themselves classic examples of the waste which occurs if a field is depleted by primary methods and abandoned without additional efforts to obtain any of the residual oil. There is a growing tendency to institute programs of a secondary nature during primary life, thereby avoiding the costly job of producing a field twice. Recent examples where this type program has been introduced to provide additional economic benefits without the costs of two distinct stages of depletion are the Anton-Irish, North Cowden, and Cedar Lake fields in West Texas, and the Elk Basin field in Wyoming.

Secondary recovery projects begun during the initial stages of depletion will usually afford the maximum ultimate recovery from an engineering and economic viewpoint. This is true not only because of increased efficiency in oil production, but also because of the minimizing of oil shrinkage in the reservoir, the extraction of liquids from the produced gas, and the saving of natural gas for future marketing. One should be aware that this type of operation is extremely difficult, if not impossible, under a competitive production program where all operators, within the bounds of statutuory regulations, produce from a common reservoir as each sees fit. The aid to highest ultimate recovery in this situation would be, of course, unitization. With unitization a greater return of profit can be expected because migration of oil in wholesale quantities to the best spots for collection can be encouraged rather than discouraged.

It is possible, of course, to initiate these secondary recovery methods on a competitive basis, but only with operational difficulty and at a sacrifice of

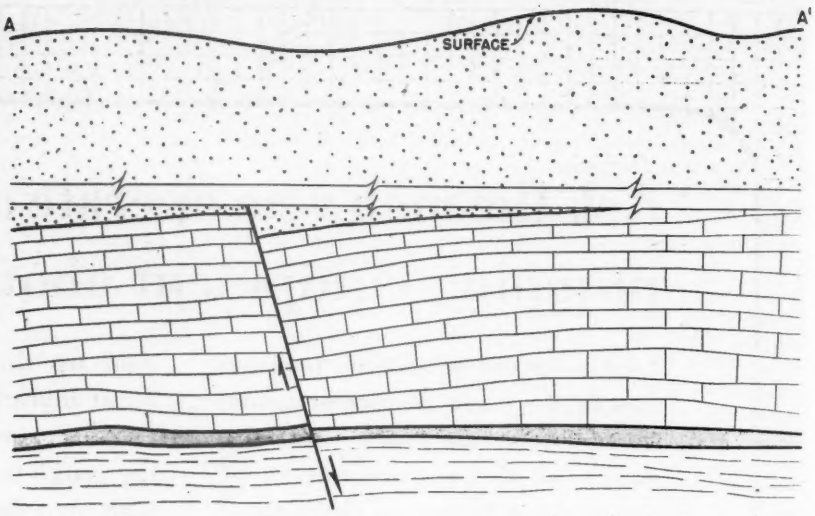
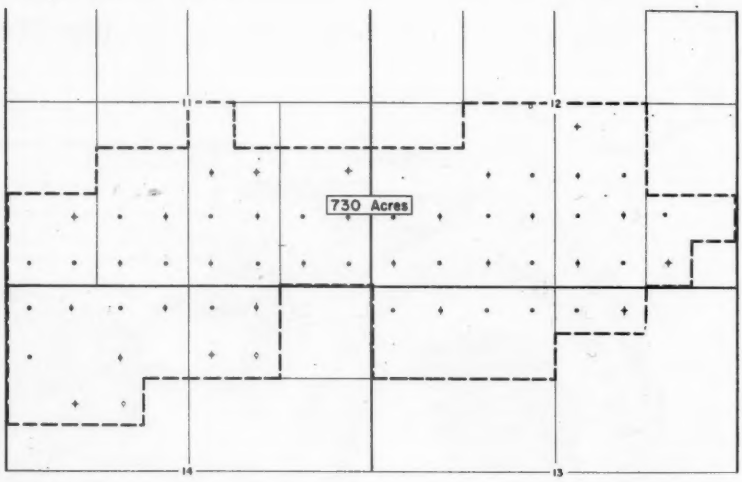


FIG. 1. Cross section—Unit A.

FIG. 2. Below, Unit A.



depletion efficiency. To demonstrate, take four units that will show the economic advantages of unitization for reservoirs of widely different characteristics and in various stages of depletion.

Unit "A"

First consider Unit "A", a volumetric type reservoir approaching the economic limit of production, which was unitized in order that a pattern water flood could be conducted. This reservoir is a monoclinic trap. A fault trending northeast-southwest bisects the field, but studies indicate that there is communication of the porosity across the fault line. Fig. 1 is an east-west cross-section of the pay sand along a line that approximately corresponds with the major axis of the field. The field is roughly two miles east and west by three-quarters of a mile north and south.

Discovered in August, 1946, the field as of October 1, 1950, had produced approximately 11 per cent of the initial oil in place from some 57 producing wells on 10-acre spacing. It was estimated as of that time that about 89 per cent of total primary reserves had already been produced.

Reservoir and fluid characteristics were as follows:

1. Initial bottom hole pressure was 914 psi.
2. Initial solution gas-oil ratio was 238 cu ft per bbl.
3. Average porosity was 18 per cent.
4. Average permeability was 150 md.
5. Connate water content was 13 per cent. There was no natural water drive or gas cap. No water except a negligible quantity of connate water had been produced in the field, and the only production problem of consequence was paraffin accumulation in tubing and flow lines.

Because of the foregoing demonstrated inefficiency of primary depletion, an investigation of the field was made to determine if a program for increasing ultimate oil recovery could be found. Engineering studies showed that a water flood, in which 23 of the existing wells would be utilized for injection, would be economical. It was decided that a modified five spot pattern was best suited to

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the plan of recovery and that no additional drilling of wells would be necessary if the field were unitized. It was further concluded that secondary operations were not desirable unless a unit was formed because (1) many wells were at the plugging stage and redrilling of the individual tracts was not justified because of the drilling cost of the wells; (2) a successful unitized flood would yield both remaining primary and secondary oil in approximately the same time as would be required to recover the remaining primary oil; and (3) elimination of the need to restrict fluid movement across lease boundaries within the unit would result in a greater recovery at less investment cost than individual or cooperative programs. Accordingly, the 730-acre area owned by eight operators and shown in Fig. 2 was unitized.

A summary of the engineering studies is shown by Fig. 3, which is a comparison of the predicted decline curves for primary competitive and unitized secondary depletion of the field. It is noted that about 13 per cent of the initial oil in place would have been produced by 1955, whereas about a 27 per cent recovery of the initial oil in place is anticipated by the end of 1959. This is an oil recovery increase of 108 per cent.

The unitization program in this field will effect the recovery of the anticipated 108 per cent additional oil in the least expensive manner.

First consider the source of the flood water. The nearest surface supply is about 4½ miles from the field in an area of seasonal drought, therefore suitable only as a last resort. The initial investment, maintenance, and operating cost of such a gathering system over the life of the flood would have approximated 18 per cent of estimated unit profits. It was found that three shallow water-supply wells could be put into operation at a considerably lower investment. Peak unit requirements were estimated at less than 5000 bbl of water per day, and these three wells would provide a supply dependable at all times. On an individual lease basis at least eight supply wells would have been needed. This cost, together with additional producing or injection well cost would have made individual projects prohibitive, especially so for the edge leases.

Total water injection costs including those of investment, maintenance, and operations were estimated to be about 24 per cent of total initial unit investment. Between 3 and 4,000,000 bbl of water will be injected into the producing formation, and the cost is expected to be well below a nickel per barrel. This is certainly less than could be expected on an individaul lease basis.

Overall economics for the unit operations should be considered. The total investment expense, including conversion and testing of wells, was quite small. A sum equal to about 5 times initial investment was estimated as direct operating expense. Summation of the various unit investment items indicated a ratio of profit to total unit investment of about 7 to 1 before taxes.

Contrast this with the state of the field as of October 1950. In the first six months of 1948 lifting costs per barrel of oil had suddenly risen sixfold, principally because of the extremely rapid production decline. This situation had become worse by 1950, and with primary depletion operating costs per barrel would have continued to increase because of continued production decline.

The cumulative effect of individual floods could not approach the recovery figures as outlined for the unit. In the first place, without unitization large volumes of oil would be untouched by the flood because several operators would not have attempted floods that required an investment for additional wells. Second, large volumes of oil susceptible to movement across lease boundaries under a unit flood would not be moved under a competitive flood for no operator will voluntarily push oil to a neighboring operator. And, third, interference between floods would have isolated oil away from the well bore.

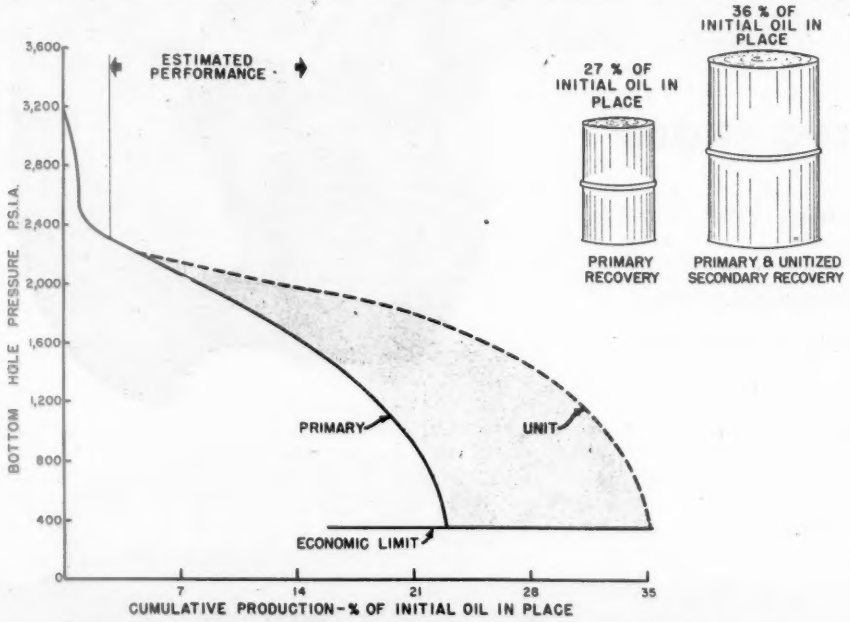

FIG. 3. Primary field and unit field decline comparison—Unit A.

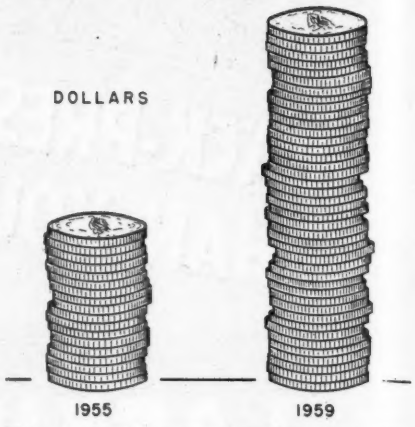

FIG. 4. Profit comparison between competitive secondary and unitized secondary—Unit A.

This clearly indicates that the formation of Unit "A" was the most economically beneficial way to attempt further recovery in the field. Every field study pointed to the alternatives of unit operation or early abandonment. Fig. 4 shows the comparison in dollars between the profit which could have been expected from competitive secondary recovery operations and the profit we conservatively expect from unitized secondary operations. It may be noted that profit from the unitized operations exceeds by 100 per cent that of competitive operations.

Another point regarding Unit "A" is that each royalty owner or working interest owner committed to the unit will receive his proportionate share of the proceeds upon a more equitable basis than would be possible under competitive production methods. The unit production, regardless of where in the unit it is produced, will be divided in accordance with the basis of participation, established in this case by exhaustive engineering study and negotiation. There will be no need for worry as to whether one particular lease is producing more or less oil than the reserves allotted to it for participation in the unit would logically support.

The last but not the least point to be made with respect to Unit "A" is that it is an outstanding example of the application of the learning acquired since the early experience of the petroleum industry. It was just this type situation of high initial well potential with subsequent very steep rate of decline that prompted pioneer operators to pull stakes for a venture into virgin territory because they had no means to cope with increasing operating costs. Today it is known that most of them did not realize that they were wasting reservoir energy and that more oil remained within the reservoir than they had captured; but the oil is there and that with proper methods of operation much of it can be recovered. The job is to take the right steps to get it.

(Concluded in an early issue.)

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NEWS

Continental Plans To Build Gasoline Recovery Plant

Plans for construction by Continental Oil Company of a $1,750,000 gasoline recovery and gas repressuring plant in the Sussex oil field in Johnson county, Wyoming, were announced by President L. F. McCollum. Location of the new plant will be in the Sussex field, about 15 miles north of Midwest, Wyoming, and construction is expected to begin in late summer, said McCollum.

The Continental installation will be the first of its type in the immediate area. The company operates a similar plant at Lance Creek and is part owner of a natural gasoline plant at Elk Basin in Wyoming.

"The Sussex field plant will contribute further to the conservation of our natural resources," said McCollum. "It will enable us to recover more than a million barrels additional oil during a 20-year period through the repressuring method of injecting gas back into the producing reservoirs in the area. It will also make available for sale about 13 billion cubic feet of natural gas and will recover approximately 300,000 bbl of natural gasoline from the compression of natural gas."

W. L. Long
Executive Vice President

Temple P. Hoffer
President

Robert R. Smith
Secretary-Treasurer

San Juanito Oil to Operate Texas Consolidated Wells

San Juanito Oil Company has entered into a contract to operate all of the properties of Texas Consolidated Oils of Dallas, according to a joint announcement made today by J. Edward Johnson, president of Texas Consolidated Oils and Robert J. Bradley, president of San Juanito Oil Company. These properties include approximately 400 producing oil and gas wells in Oklahoma, Texas, Louisiana, New Mexico, Kansas, and California.

M. D. Oliver, chief engineer of San Juanito Oil Company, has been named as operating vice president.

Oil Field Service Firm Is Set Up in Dallas, Texas

A new oil field service company has been organized under the name of Pressure Services, Inc., with headquarters at 137 Walnut Hill Village, Dallas, Texas. W. L. (Luke) Long, executive vice president of the new company, has announced that PSI's operations will be largely in the Gulf Coast and Mid-Continent fields, though they will extend to all other areas in this and foreign countries.

Pressure Services, Inc., according to Long, will specialize in running and pulling pipe under pressure, and will provide technical assistance and service for operators of flowing and pumping dually completed wells.

Associated with Long in the management and operation of Pressure Services, are Temple Hoffer, president, and Robert R. Smith, secretary- treasurer.

Long, formerly manager of the tubing service division of Otis Pressure Control, Inc., is manager of field operations and equipment for the new company.

Temple P. Hoffer, formerly special services division manager of Otis Pressure, is technical and business manager of PSI. A petroleum engineering graduate of the University of Texas, Hoffer has been associated with the petroleum industry for some 14 years in various capacities.

Robert R. Smith, formerly superintendent of the special services division of Otis Pressure, will engage in both field and business operations of Pressure Services. Smith is a graduate of the business school of the University of Akron, Akron, Ohio.

Los Angeles Nomads at the April meeting had the above guests: (back row) Dan Dodge, and Elwyn Fogelberg, Kuwait Oil; R. Ragland, N. V. Caltex Pacific; C. C. Dorsey, Arabian American Oil Company; Byron Adams, Texas Petroleum, Venezuela; (middle row) Joe Streeter, oil division, Canadian Bank of Commerce, Calgary; J. R. Ramirez, Caltex from Sumatra; A. M. Thornton, Shell Oil, Colombia; Pierre Maillet, SN-REPAL, Algeria; M. Ricaud, SICA Algiers; (bottom row) P. K. Bunke, Texas Petroleum, Venezuela; G. H. Atkins, Basrah Petroleum; Jean Bosson, commercial attache, French Consulate; A. C. do Lago, Consul of Brazil.

Speaker at the Los Angeles Nomads' April meeting was Dr. A. T. Polyzoides (left), speaker, lecturer, and professor at the University of Southern California. He is greeted by W. A. (Bill) Wilson, of Web Wilson Oil Tools, president.

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WICHITA Air-Tube disc clutches

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If a manufacturer deems one type of clutch is the best, then why does he use one type of clutch on the drum drive, another in the transmission, perhaps another on the engines and even another on the pump drive? If one type of clutch is best, then ONLY THE BEST SHOULD BE USED! WILSON is the ONLY Rig Manufacturer using ONE TYPE OF CLUTCH ON ALL DRIVES! AND WILSON SINCERELY BELIEVES THIS IS THE WORLD'S BEST CLUTCH.

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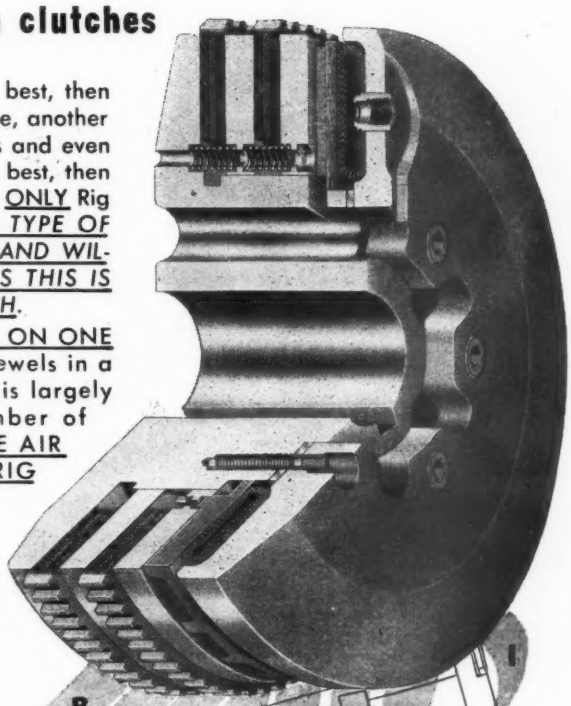
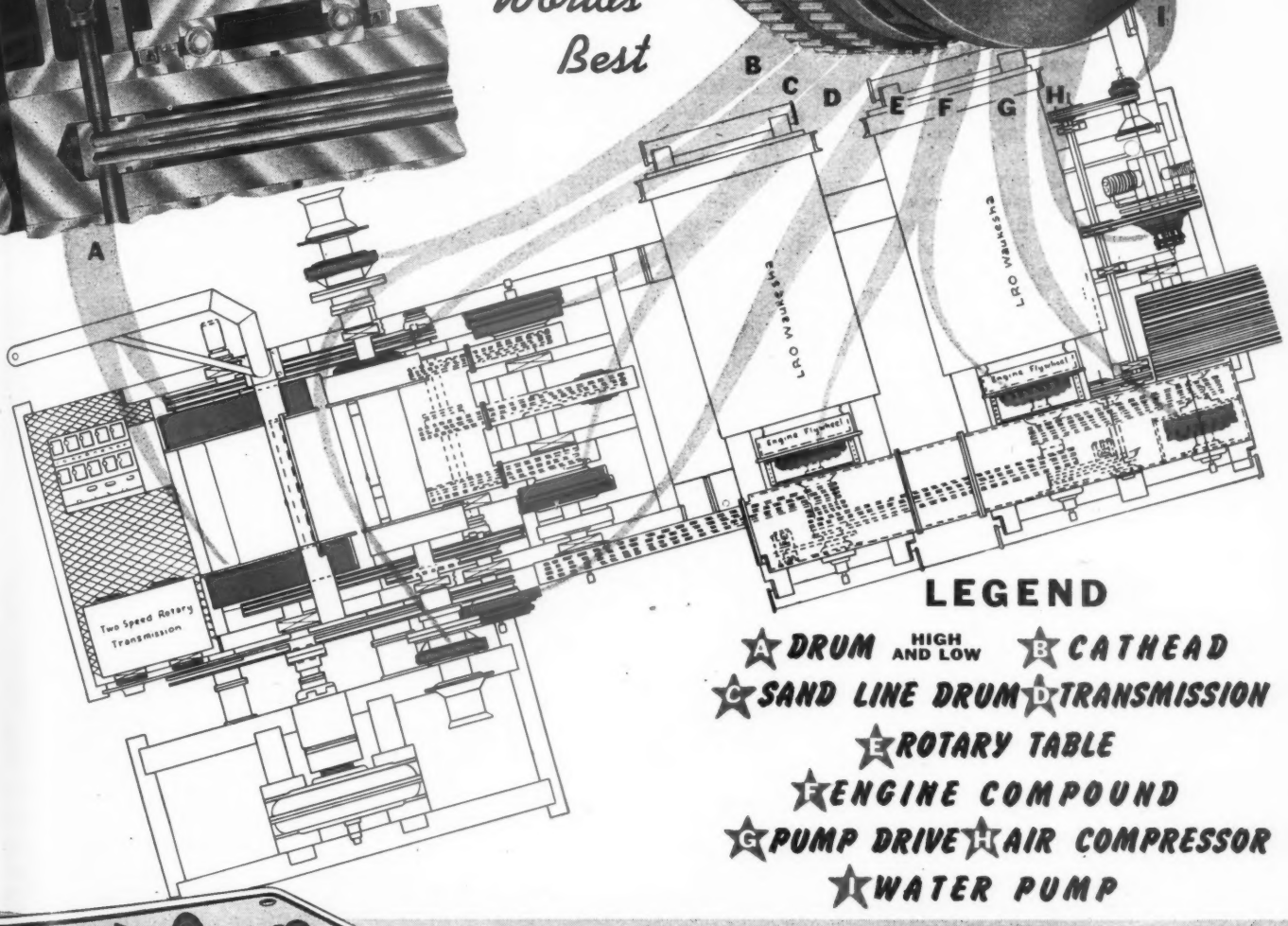


The World's Best



LEGEND

A DRUM HIGH AND LOW — B CATHEAD
C SAND LINE DRUM — D TRANSMISSION
E ROTARY TABLE
F ENGINE COMPOUND
G PUMP DRIVE — H AIR COMPRESSOR
I WATER PUMP

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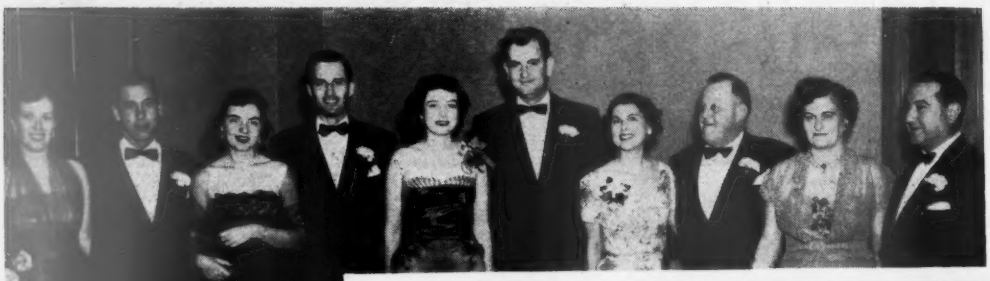

Dallas-Fort Worth Nomads Hold Dance

Dallas-Fort Worth Nomads held their annual formal dinner dance recently at the Hotel Adolphus, Dallas. In the receiving line were Mrs. Davidson, R. E. Davidson; Miss Gloria Gibson, E. F. Shiels; Mrs. Leseman, W. T. Leseman; Mrs. Berlin, Courtney J. Berlin; Mrs. Mussler, J. A. Mussler.

Right, are: Mrs. Berlin; Morris Finney, Pure Oil; Mrs. Watson; Homer Key, R. J. Caraway Oil Company; Mrs. Finney; Rex Watson, Ray-Rex Drilling; Mrs. Key; Courtney J. Berlin, Baker Oil Tools (extreme right).

Heck Speaks to Members Of Eastern District API

The key to unlock part of the vast underground oil resources, heretofore trapped below the ground in the Appalachian Basin oil producing areas has been found, it was revealed by Edward T. Heck, of the Minard Run Oil Company, Bradford, Pennsylvania, retiring chairman of the eastern district of the American Petroleum Institute's production division, at the conclusion of the three-day annual meeting of the production group.

"Due to the ingenuity of the producers in the oil industry," Heck said, "over 300,000,000 additional barrels of Pennsylvania grade crude oil, which otherwise never would have been recovered, have been brought to the surface as a result of artificial methods of stimulating its flow."

Pennsylvania grade crude oil is produced in the four-state area of Pennsylvania, New York, Ohio, and West Virginia.

Danvers Builds Road to Location in an Utah County

Don Danvers, Danvers and Wheeler, independents, reports that he is building a road in the San Juan Canyon in Southeastern Utah. Destination is Slickhorn Canyon and the location of an early Pennsylvanian producer. Exact location has not been made, but will be in San Juan County, and will test to Granite, Danvers stated.

The road, which is suitable for heavy equipment, is nearing completion from Mexican Hat Trading Post about 35 miles westward down into the gorge of the San Juan River. It is following the trail blazed in 1908 by pioneers, whose narrow, dangerous trail is still discernible and whose drilling equipment, by today's standards, was very small.

Shell Establishes New Montana Production Office

Shell Oil Company has established a district production office in Glendive, Montana, according to an announcement by J. E. Clark, Rocky Mountain division manager in Casper, Wyoming. The new office was created to handle the company's increasing activity in the Montana part of the Williston Basin, particularly in the development of its two discovery fields, Richey and Pine, as well as operations in the Glendive field.

The company plans to have five strings drilling development wells in the Richey field and two in the Pine field. Also, a number of wildcat wells will be drilled in the basin this year by Shell.

Simultaneously with the announcement of the new office, Clark named the following staff personnel for the Glendive production office:

F. H. Taylor has been appointed district superintendent in charge. His staff will include: R. H. Woodward, district exploitation engineer; W. E. Spear, district mechanical engineer; E. A. Wick, purchasing and stores manager; F. A. Sikes, production foreman.

Drilling foremen will be H. H. Brigham, W. C. Thompson, E. T. Mooney, M. D. McCollim, and T. Braswell will serve as chief clerk. Other staff members will include engineering and drafting personnel.

Williston Basin Pioneers gathered in Williston, North Dakota, recently to celebrate the first anniversary of the discovery of oil. Shown here are: Bob Wire, president of Loffland Brothers, drillers of the discovery well of Amerada Petroleum Corporation; A. Jacobson, president of Amerada; Norman Brunsdale, governor of North Dakota; Clarence Iverson, owner of the discovery well; and T. P. Tarwater, general division manager for Mid-Continent Supply Company, equipment suppliers.

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is one great assurance of "perforating jobs done right!"

You don't get much chance to see this button, because usually your Lane-Wells man won't have it on his work shirt. But you'd be surprised to know how many Lane-Wells men have these buttons, which tell of five, ten, fifteen or more years of continuous service with Lane-Wells.

These service buttons represent your greatest assurance of a job done right, because they represent oil field experience—and the reservoir of knowledge that comes with it. The men who can wear these buttons have met nearly every perforating problem an oil well can throw at you, and when the answers weren't in the book, they've made their own answers—and seen them become standard practice in one field after another. The thousands of man-years of experience these buttons represent—the oil field know-how gained in 170,000 perforating jobs—are why...

Operators from California to Kentucky can tell you

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Continental Supply Holds Annual Sales Meeting

Continental Supply Company held its 12th annual sales meeting in Houston, Texas, recently. Over 200 were in attendance, including district managers, assistant district managers, and field representatives from the company's 80 stores and offices, as well as principals in the sales and engineering divisions of the company.

The theme of the meeting was "Know Your Products." Headquarters for the conference were at the Rice Hotel.

In keeping with the purpose of the conference, each session was one of demonstration so that all personnel would be fully informed on latest development in equipment they handle. The entire day Monday was spent in the plant of the Emsco Derrick and Equipment Company, at which time the group inspected various pieces of Emsco equipment, including the new J-1100 rig and A-126 portable mast. Each phase of this tour was accompanied by explanatory talks by engineering and construction specialists. The days' activities were climaxed with a dinner at San Jacinto Inn on the Houston ship channel.

Continental Supply Company warehouse was visited the morning of the second. After an inspection of these

1. J. A. Mussler, Continental's general manager of sales; J. H. Berry, managing director, Canadian operations; E. E. Tyer, assistant district manager, South Texas district.
2. Frank I. Brinegar, left, Continental executive vice president, discusses features of Totco equipment with H. H. Peters, vice president of Technical Oil Tool Corporation.
3. Jack Davis, Continental's manager of pipe line division, left, discusses a Gardner-Denver compressor, with R. J. Bauer, Southwestern manager of Gardner-Denver.
4. E. N. Wood, district manager, Arkansas, North Louisiana, Mississippi, Southeast Texas; Charles H. Fischer, district manager, Illinois, Indiana, and Kentucky; R. L. Collier, district manager, West and North Texas and New Mexico; and R. A. Brewer, district manager, Kansas and Oklahoma.
5. G. V. Leece, vice president, Gardner-Denver Company, points out construction details of the bearings on a Gardner-Denver mud pump to Allen Whitesides, manager of Continental's drilling equipment division.
6. J. A. Mussler, general manager, sales, Continental; Frank I. Brinegar, executive vice president, Continental; Paul Courtney, vice president and general sales manager, Emsco; J. T. Tucker, sales manager, Emsco, in luncheon line at Emsco plant.
7. W. T. Powell, Emsco Derrick and Equipment Company vice president, is shown at the controls of one of Emsco's latest drilling rigs, explaining certain innovations in the rig to Frederick M. Mayer, president of Continental.
8. Bill Kinder, vice president, Emsco D+B division; Marcel Ricaud, Continental's agent associated with SIECA in Algiers, North Africa; C. J. DeLay, manager Continental's export division, New York; Pierre Maillet, engineer with S.N., Repal, Algiers; Julio Zumeter, executive manager, export division, New York; Hans Fraenkel, N. Y. representative, SIECA.

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On your Pulling jobs remember—when you call the Fishing Tool Division of Wilson Supply Company—you get the right men and the right tools to get the job done quickly and successfully.

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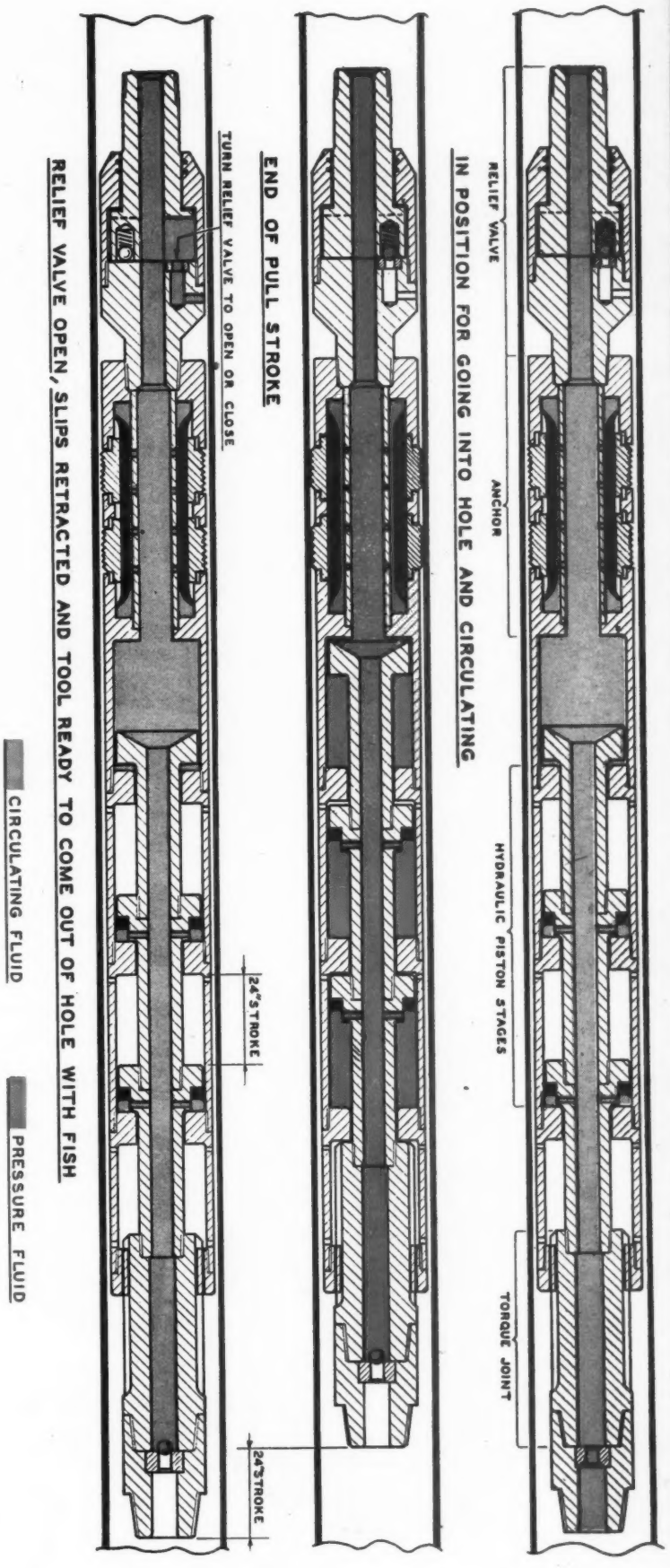
RELIEF VALVE OPEN, SLIPS RETRACTED AND TOOL READY TO COME OUT OF HOLE WITH FISH
TURN RELIEF VALVE TO OPEN OR CLOSE
CIRCULATING FLUID
PRESSURE FLUID
END OF PULL STROKE
24" STROKE
24" STROKE
IN POSITION FOR GOING INTO HOLE AND CIRCULATING
RELIEF VALVE
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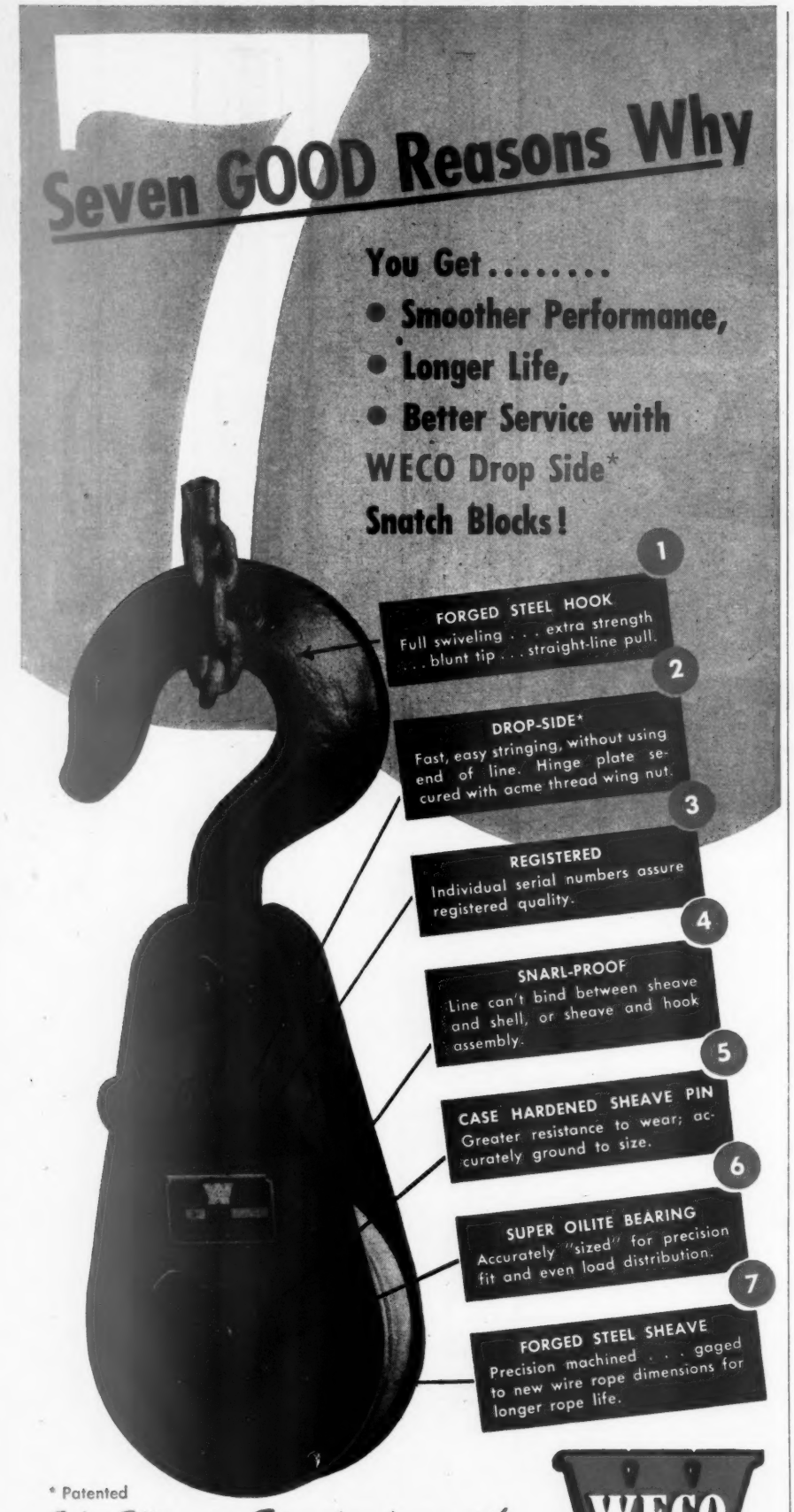
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Greater resistance to wear; accurately ground to size.
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Accurately "sized" for precision fit and even load distribution.
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Precision machined . . . gaged to new wire rope dimensions for longer rope life.
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Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment

facilities the group went to the Broderick and Bascom Rope Company plant for lunch, followed by an inspection tour.

The 2-day meeting was brought to a close the second day with a general session at the Rice Hotel.

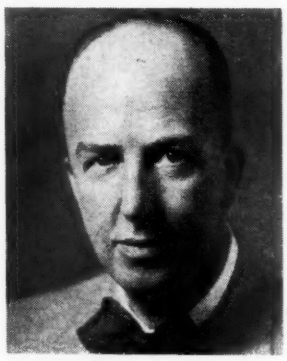
Executives of Continental attending the meeting were W. J. Morris, chairman of the board; Frederick M. Mayer, president; Frank I. Brinegar, executive vice president; Noble A. Endicott, vice president in charge of Gulf Coast operations; Dan Bailey, vice president, in charge of finances, and Jack A. Mussler, general manager of sales.

Representing associate manufacturers were: John de Hetre, manager, Oil Country Tubular Sales.

Emsco Derrick and Equipment Company was represented by W. T. Powell, vice president; Paul Courtney, vice president; S. A. Martin, Houston plant manager; J. T. Tucker, sales manager, and A. A. Ashton, chief engineer.

Others in attendance were: G. V. Leece, vice president, Gardner-Denver Company; Joe H. Bascom, vice president, Broderick and Bascom Rope Company; H. H. Peters, vice president, Technical Oil Tool Corporation; Ben F. Ruether, vice president, New York Belting and Packing Company; Martin Walter, Jr., president, and Robert A. Snyder, vice president, of New Bedford Cordage Company.

On the evening preceding the meeting, a dinner of the "Twenty Five Club" was held at the Rice Hotel. Honored were all Continental employees attending the meeting who have been with the company 25 years or more.



T. H. Acres

API Production Men Are Meeting in Los Angeles

More than 1200 western oil men, from drillers to production bosses, are holding a two-day round of "shop talk" in Los Angeles this month at the 25th annual spring meeting of the production division, Pacific Coast district of the American Petroleum Institute, T. H. Acres, Sunray Oil Corporation, general chairman for the meeting, announces.

Frank M. Porter, New York, president of the American Petroleum Institute, and J. C. Donnell II, API vice president for production and president of the Ohio Oil Company, are attending the two day session at the Biltmore Hotel, Acres said.

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Whatever your needs are in oilfield supplies
There's one place to get them without useless tries,
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For—midday or midnight—we ne'er "close our doors."

From rig tip to drill bit, betwixt and between,
We carry each item of which drillers dream,
And when down-time's your headache just give us a try;
When Speed can mean Dollars It's "UNITED SUPPLY."

Uncle Sandy Says:
There's more truth than poetry in this!

YOU CAN RELY ON US UNITED SUPPLY!
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COURTESY • SERVICE • DEPENDABILITY

What's Doing in Drilling

Alabama Field Gets Second Oil Producer

The second producing well has been brought in in the Pollard field of Escambia County, Alabama, by Humble Oil and Refining Company. It is the company's A. Lister No. 1, which is pumping at the rate of about 125 bbl of 25.6 gravity oil daily. The new well is Humble's third confirmation test to be drilled near the original field opener, the A. W. Moye No. 1. The two previous attempts following the discovery resulted in dry holes.

The A. Lister No. 1 was completed in the Lower Tuscaloosa sand through casing perforations at 5977 ft to 5982 ft. Total depth is 5982 ft. This second well is 1360 ft south of the Moye No. 1, completed for a calculated daily flow of about 315 bbl of oil.

New Oil Zone Found in North Dakota Discovery

A new pay discovery, deepest in the state of North Dakota, has been struck at the Math Iverson No. 1, in Williams County, according to O. E. Walton, chief geologist for M. B. Rudman, Texas independent, and Critchell Parsons, president of Tioga Petroleum Corp.

The new producing zone, flowing gas and oil with burning in the pits, is at 11,740 to 11,770 ft. The well acidized with 3000 gal after 180 bullets were used at 6 bullets a foot. The flow was substantial with the well cleaning itself. Walton says that the amount of flow per hour has not yet been determined. Flowing pressure is 1250 lb psi through one quarter inch choke.

This newest and deepest producing zone in the state is 100 ft lower than Amerada's initial producing well in the Williston basin, according to Walton. The gravity of oil is 45 deg with the pay section estimated to be 11,690 to 11,770, some 80 ft of effective pay. This is the seventh commercial pay zone cored and tested at the Math Iverson, the first pay at 8367 to 8500 ft in Madison lime, flowing 20 bbl an hour, the second at 9873 to 9922 ft, and the third 9873 to 10,489 in the Devonian section. The well ran seven pays through the Devonian not including the Madison, which flowed 50 bbl an hour on test November 1.

Rudman and Parsons were the first independent producers to bring in a well in the Dakota area.

Phillips Drills Field Well

Phillips Petroleum Company has a new well in the Southeast New Hope pool of Garvin County, Oklahoma. It is the No. 1 Mattie plugged back to 7593 ft. The well was perforated between 7397-7416 ft, after which it flowed 171 bbl of 39.4 gravity oil in 17½ hr through a ¼-in. choke with a gas-oil ratio of 1364 to 1.

Unionville Field Well Brought In in Louisiana

Southwest Gas Producing Company and W. C. Feazel Interests have a one-mile east outpost to the Unionville field of Lincoln Parish, Louisiana. A drill-stem test has been run of the interval 8865-71 ft, using ¼-in. chokes and 2500 ft of water cushion. Tool was open 5 min and top working pressure reached 1150 lb. Recovery included 46 ft of condensate and 18 ft of gas cut mud.

Wilcox Zone Opened in East Central School Field

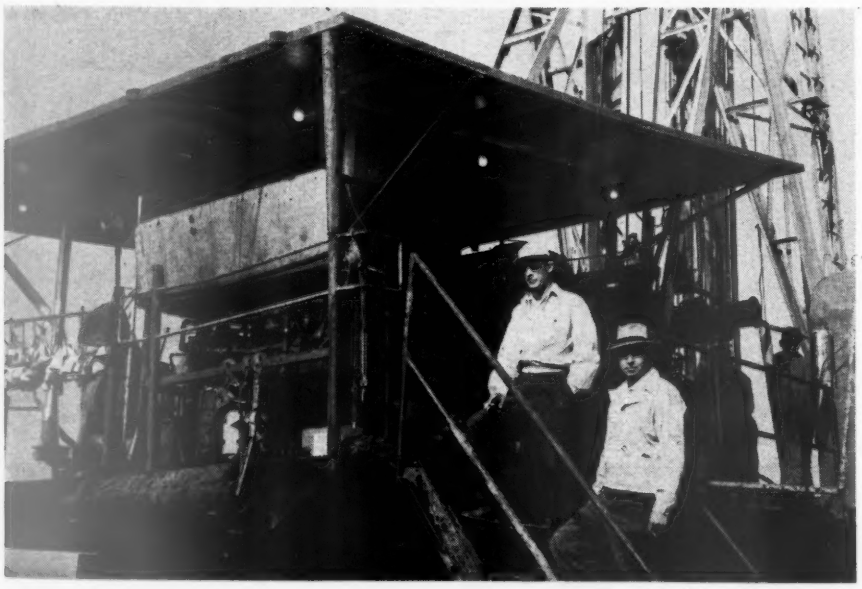
Production has been opened in the second Wilcox sand in the East Central School field, Logan County, Oklahoma. New well is the Fordee-Rhoades Oil and Aberdeen Petroleum Company's No. 1 Allen. Bottomed at 5108 ft with casing set in top of zone at 5090 ft, the well kicked off to clean itself, and was flowing a steady 25 bbl of oil per hour on first production test.

Reef Field Extended

A one-quarter mile southwestern extension of the Adair Wolfcamp Reef limestone field of Terry County, Texas, is provided in the completion of Cities Service Oil Company's Newton No. 1 for a flowing potential of 937 bbl of oil daily. Flow was through a 32/64-in. choke. The well is producing from the Wolfcamp Reef limestone from 8512 to 8549 ft.

Nigeria Test Well Is Below 8600 Ft

Shell D'Arcy Development Company's exploration well at Owerri, Nigera is now more than 8600 ft deep. Sandstone strata have been recently penetrated and there have been shows of gas, according to Anglo-Iranian Oil Company. Shell D'Arcy, a joint undertaking of Anglo-Iranian and Shell groups, is conducting an intensive search for oil by geological and geophysical methods and by test drilling. The Owerri well, 70 miles north of Port Harcourt in the Niger delta, is the first deep test-well the company has drilled.



John C. Head, Jr., left, and T. J. Alexander, at the International, Inc. rig operating in Glasscock County, Texas, drilling Currie No. 4 for Plymouth Oil Company.

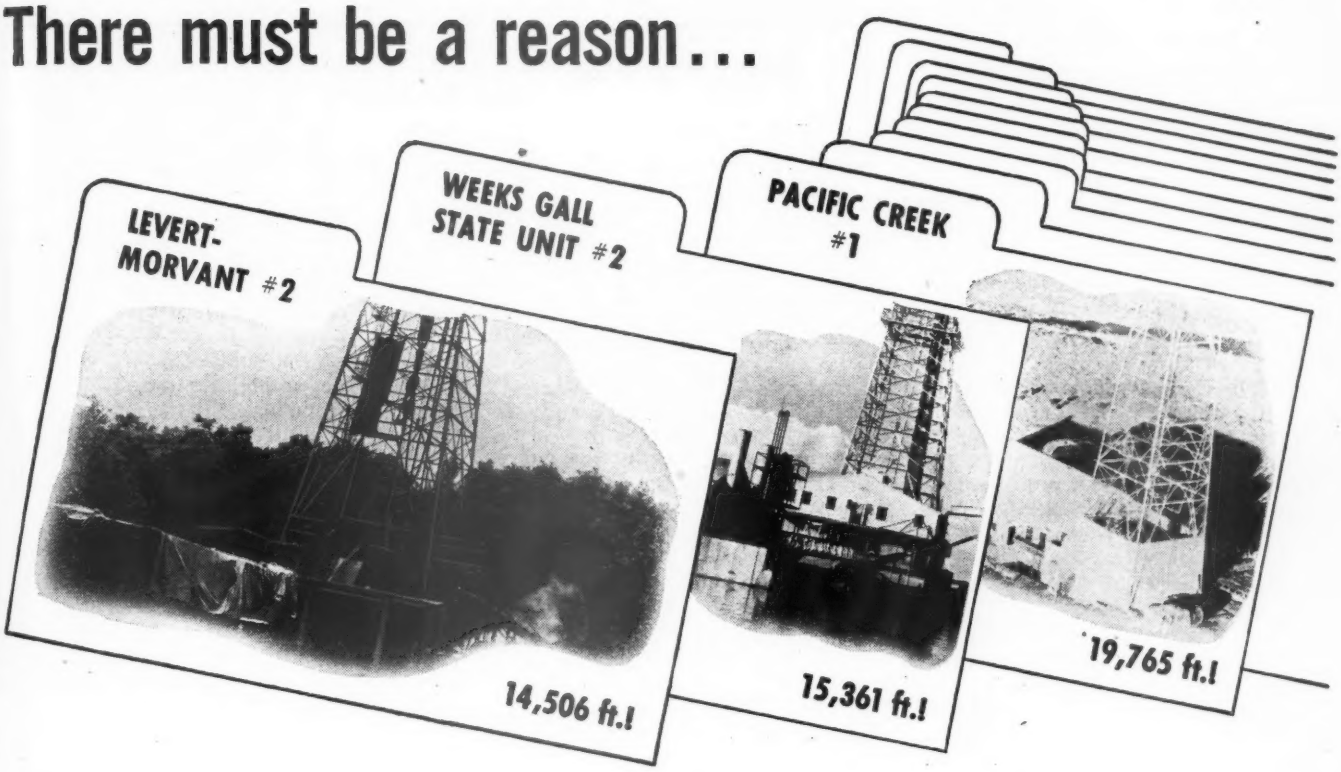
Drilling Firm to Extend Work to Latin America

T. J. Alexander, president of International, Inc., which recently began drilling contracting in Midland, Texas, has announced that the firm will extend its operations into Latin America. The company is now drilling for Plymouth Oil Company in Glasscock County, Texas.

Alexander formerly represented IDECO in Venezuela in the technical service department. Shortly after the first of this year he and John C. Head, vice president, formed International, Inc. Alexander is a graduate of the University of Texas.

Head spent four years in South America for the Carter Oil Company on loan to International Petroleum Company and later was general superintendent of Cia de Petroleo Ganso Azul Company in Lima, Peru. He is a graduate of the University of Oklahoma. On his graduating his first employment was with Kerr-McGee Drilling Industries.

There must be a reason...



why so many deep wells are cemented with UNAFLO*

THE REASON is Unaflo's retarded set that gives more time to get the cement in place down a long hot string. And drillers know they can rely on Unaflo's dependable performance.

Unaflo's *retarded* set keeps slurries fluid and pumpable during the entire period of retardation despite heat and pressure. Unaflo's setting time is *delayed* not just slowed.

That's vital in the deep ones. And it's a comfortable safety factor in emergencies. Easier pumpability permits you to do a better job of placing the cement behind the casing.

So on your next job, take a tip from the deep pay producers—let Unaflo protect your investment three ways:

1. EASY PUMPING—**Unaflo's high *initial* fluidity makes pumping easier right from the start.**

2. SUSTAINED FLUIDITY — **Unaflo stays fluid and pumpable throughout the retardation period. There's ample time, even in emergencies, to get the cement in place.**

3. HARDENS NORMALLY—**Unaflo, after its retarded period, makes a strong, tight seal – resistant to sulfate waters.**

SEND FOR FREE BULLETIN—gives data tables of Unaflo's well-bottom performance and that of our other cements. For your copy write: Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

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OIL-FIELD CEMENTS

Unaflo Retarded Oil-Well Cement
Resistant to Sulfate Waters
Atlas Portland Cement—Type I
Atlas Portland Cement—Type II
Resistant to Sulfate Waters
Atlas High-Early Cement—Type III

PE-U-126

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*

Drilling

North Dakota Field Is Extended by Amerada Well

The first oil field in North Dakota, Williams County, has been extended 1¾ miles west with completion of Amerada Petroleum Corporation's No. 1 Knutson. The new well flowed 540 bbl of 43.2 gravity crude and 725,000 cu ft of gas in a 24-hr production test from the Madison limestone at 8472 to 8500 ft.

Sun Completes Well in Mississippi Oil Field

Sun Oil Company has completed its No. 10 Annie G. Barnum in South LaGrange field of Adams County, Mississippi. The new well flowed at the rate of 181 bbl of 43.3 gravity oil per day through various sized chokes on completion potential. Production is through casing perforated at 6401½-04½ ft. It was bottomed at 6406 ft.

Kentucky Gas Well Drilled

E. J. Evans fee has completed a new oil well in Big Sand Gas field area in Knott County, Kentucky. It is the United Carbon Company 33. After shooting Maxon sand from 1206 to 1328 ft, total depth well made 15 bbl of oil in a day.

Rotary Rigs Operating in Oil Fields of United States and Canada*

Weeks	Total	Gulf Coast	Pacific Coast	Illinois Oklahoma Kansas	Rocky Mountain Canada	New Mexico West Texas	Arkansas Louisiana Texas	North Texas
(March).....								
Fourth.....	2908	602	159	570	363	726	156	332
Fifth.....	2879	612	156	573	330	733	144	331
(April).....								
First.....	2974	628	159	624	348	747	149	319
Second.....	2932	617	160	629	327	729	147	323

* As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

Cities Service Adds Well To Texas Oil-Gas Field

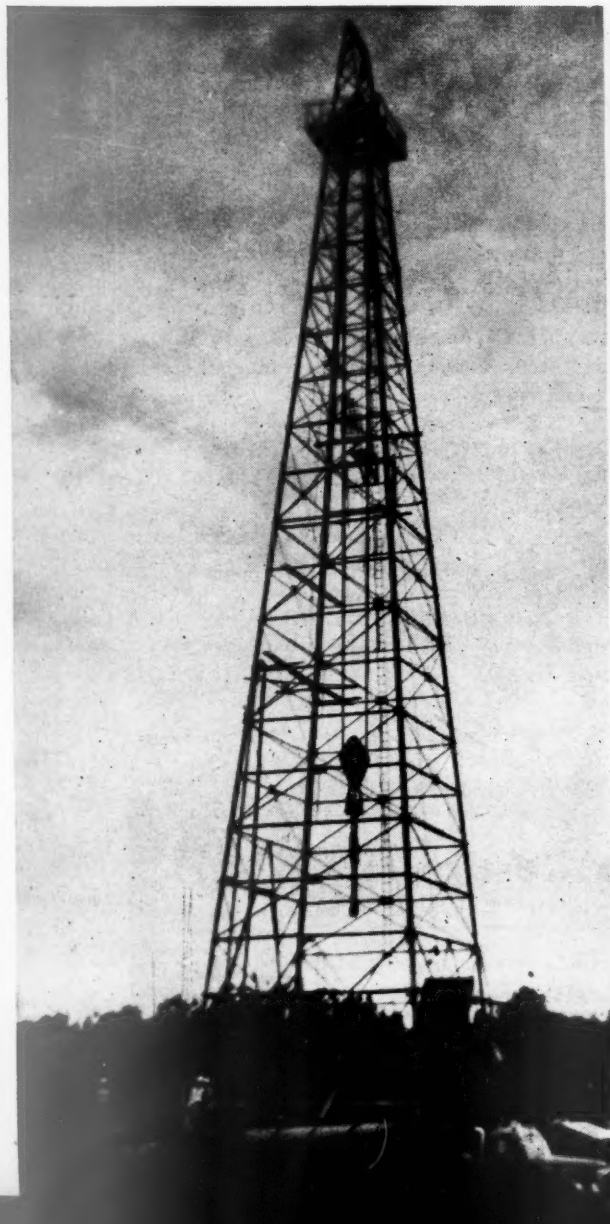
A new completion for the multi-pay Columbus oil and gas field of Colorado County, Texas, has been reported by Cities Service Oil Company. The company's Gay B No. 1 was dually completed at a total depth of 10,502 ft for an open flow of 5,400,000 cu ft of gas from 8095 to 8100 ft and a open flow of 17,500,000 cu ft from 8750 to 8755 ft.

Pray Has Two-Zone Well

Max Pray has added a two-zone producer to the Lindsay pool of McClain County, Oklahoma. Drilled to 11,070 ft, with 7-in. casing, the well set at 11,064 ft, the Chimney Hill was perforated at 9840 to 9910 ft and the Bromide at 10,860-940 and 10,970 to 11,010 ft. In a test of both zones together, the well flowed 320 bbl of oil in 24 hr.

Colorado Field Well Added

Sherrod and Apperson of Tulsa, Oklahoma, and Earl Siler, of Oklahoma City have found oil at their first test in the Keota field of Weld County, Colorado. Their No. 1 Gillette flowed 22½ bbl of oil in 5 hr on a ½-in. choke for 5 hr, then did 10 bbl of oil hourly through a ⅜-in. choke, from the Dakota sand at 7315-60 ft. A second well was begun.



Standing round the J. B. White, Tensley Unit No. 1 are Lee Wood, L & G Oil and Royalty Company; D. B. Mitchner, M & M Trucking Company; J. B. White; Alma Floyd (looking down), Spartan Drilling Company, and Dot Wade, Jake L. Hamon. At left is drilling rig at the Tensley Unit No. 1.

Dallas D & D Members Watch Well Come In

Members of the Dallas Desk and Derrick Club went on a 2-day trip to Louisiana recently to watch a well that was being brought in. Sponsor of the trip was J. B. White, independent operator. Well was the Tensley Unit No. 1 in Haynesville field, Claiborne Parish. It was drilled to the Smackover limestone, at a total depth of 10,560 ft.

Dallas club members together with the Shreveport D & D girls were entertained at dinner by White.

Making the trip were: Jerry Balbin, Blackwood and Nichols; Martha Hughes, Republic Natural Gas; Cleo Jones, Seaboard Oil; Pia Marie Joerger, J. B. White; Dot Wade; Clara Keithly, Magnolia; Alma Floyd; Reberta Webb, Dr. J. C. Karcher; Dorothy Prim, N. R. Royall, Jr.; Lee Wood; Penny Eades, Core Lab; Dorothy Jones, Humble; Peggy Stanley, Larsen and Thomas; Sue McCarter, AAODC.

THE NEWS THAT'S SWEEPING THE OIL FIELDS

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GLOBE "2-CUTTER" Integral JET ROCK BITS

Pioneered by Globe, the integral jet principle has made possible faster drilling, with fewer bits, at lower cost. With power rigs or steam rigs, with large rigs or small rigs, the story is the same . . . faster, more efficient, more economical drilling, with Globe "2-Cutter" Integral Jet Rock Bits.

Globe "2-Cutter" Jet Bits were painstakingly engineered to handle the high mud volume and pressure of jet drilling. They've had their "work outs" in Texas, Oklahoma, California, in all field conditions. Here is a performance-tested answer to the problem of rising drilling costs. Your Globe representative will help you switch over to the new, dollar-saving jet bits. Call him today for detailed, factual information.

Globe Jet Rock Bits are now available in all popular sizes from 8½" to 15", in types SS2C, S2C, M2C, MH2C, and H2C.

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Exploration Activities

Amerada Finds Oil in New North Dakota County

Amerada Petroleum Corporation has opened a new oil field in McKenzie County, North Dakota, with completion of its Bakken No. 1 wildcat well, flowing from the Madison formation. The well is flowing 49.0 gravity crude at 8312 to 8350 ft. It had flowed 82 bbl of oil and 228,000 cu ft of gas through a ¼-in. choke in 10 hr. Flow was coming from an interval that had flowed during a drillstem test to discover Madison oil in the state.

Amerada Petroleum Corporation has a new producer in McKenzie County, North Dakota. It is the company's No. 1 Benhommer Risser, which flowed an average of 11 bbl of oil per hour of 40.6 gravity oil from the Devonian limestone at an interval of 11,600-30 ft. Gas was through ¼-in. choke. Amerada has plugged the hole back to 9598 ft, and is preparing to test the Madison limestone.

Amerada completed its seventh well in North Dakota. The new well in Williams County is the No. 1 C. Nylander, which is flowing from the Madison lime. The well is hooked up to flow lines at 8696 ft, and on test flowed 369 bbl of oil for 24 hr through ¼-in. tubing choke. It extends the Beaver Lodge pool one mile eastward.

B-A Completes New Well In Colorado Sector

British American Oil Company, Ltd., has opened a new oil field in the Denver-Julesburg Basin, Logan County, Colorado. It is the company's No. 1 Schwake, some 16 miles northeast of the Yenter field, which has been completed for an initial potential of 36 bbl of 37.3 gravity oil per hour from approximately 5300 ft.

Oklahoma Well Testing

The Texas Company has a new well, No. 1 Bolles-Bell Unit in Garvin County, Oklahoma. The well flowed 7 bbl of 42 gravity oil, without any water in 24 hr through a ¼-in. choke from perforations in the First Gibson sand between 6605-29 ft and between 6604-34 ft. Plugged back depth is 7479 ft. It also flowed 152 bbl of 44 gravity oil from the Second Bromide through perforations between 7454-76 ft through a 35/64-in. choke, in 24 hr.

Texas Discovery Made

A discovery well has been completed in the Palo Pinto reef zone, Haskell County, Texas, by Youngblood and Foree. The well is the No. 2 Kleiner Estate, which flowed and pumped 102.64 bbl of oil a day on initial test. It had a gas-oil ratio of 378-to-1, and is producing from 3340-47 ft.

Caltex Joins Australians In Extensive Oil Search

Announcement has been made of exploratory operations in Western Australia by a new company, the West Australian Petroleum Proprietary, Ltd., in which the Caltex Group has joined forces with an Australian company, AMPOL, to explore over 350,000 sq miles of virtually desert country.

Some preliminary geological work has been carried out, and the joint companies' first field party recently returned from the area. With the information they have obtained they will recommend exact site of drilling the first well, and other information.

West Australian Petroleum's initial goal is the drilling of one well at a location some 800 miles from the nearest deep water port, Fremantle.

This Northwest Basin of the Australian continent is arid desert table land with bare stone outcroppings and a porcupine grass called spinifex which cuts like a razor. Besides the hot sun and only an occasional dirt road, there is the seasonal monsoon that blows in from the Indian Ocean, and a problem of water supply.

Exploratory Well Drilled Off English Coast

The Anglo-Iranian Oil Company has reported that an exploratory well will be drilled on the Isle of Wight off the South Coast of England, the first time in the island's history. The well, drilled by D'Arcy Exploration Company, is now below 2000 ft. The Isle of Wight drilling location is almost exactly in the middle of the island, about a half-a-mile southwest of the Village of Arreton.

Oklahoma Well Test Flows 595 Bbl of Oil Second Day

A new well, flowing 476 bbl of 41.5 gravity oil on first day of testing, has been brought in in Logan County, Oklahoma. It is Fordee Rhoades and Aberdeen Petroleum Company's No. 1 Alien. On the second day of testing, the well produced 595 bbl of oil through a ¾-in. choke. It has been pinched back to 24/64-in. choke for the remainder of the test. Total depth is 5108 ft. It is ¾ths of a mile away from nearest production.

Tri-State Depth Record Set

Superior Oil Company has set a new depth record in drilling in the Tri-State area of Illinois, Indiana, and Kentucky. Its No. 17 H. C. Ford "C Lease" in White County, Illinois, has stopped drilling after reaching a depth of 7685 ft. The company has set 7-in. pipe at 5100 ft. Previous Tri-State record was a 7207 ft St. Peter test drilled in 1940.

Richfield Opens New California Oil Area

Richfield Oil Corporation "has apparently made a significant field discovery in the south end of the San Joaquin Valley," California company officials announced. The discovery well, KCL 85-29, west of Wheeler Ridge in the wildflower area 25 miles south of Bakersfield, was completed from a depth of 9757 ft.

The well was completed flowing at a high rate but, due to lack of storage facilities, was quickly pinched back. On a 3-hr gage the well produced at the rate of 1170 bbl a day through a 17/64-in. bean of 35.3 gravity oil with a 2 per cent cut. Gages showed 2800 lb tubing pressure and gas production was estimated at 1,500,000 cu ft per day. The well began flowing naturally without swabbing while circulating the 84-lb drilling mud out of the hole.

Seven-inch casing is cemented at 9600 ft and the 157-ft-thick producing zone is believed to be sand of the Eocene age.

Cities Service Well Finds First Showing of Oil

First show of oil has been reported at Cities Service Oil Company's test well, Nunn No. 1, in Reagan County, Texas. In a 2½-hour drillstem test from 6483 ft to 6647 ft in the Spraberry, which was topped at 6541 ft, operators recovered 250 ft of oil and gas-cut mud and 2767 ft of oil. They are preparing to drill ahead.

Nearest production to the Nunn No. 1 is 1½ miles to the northeast.

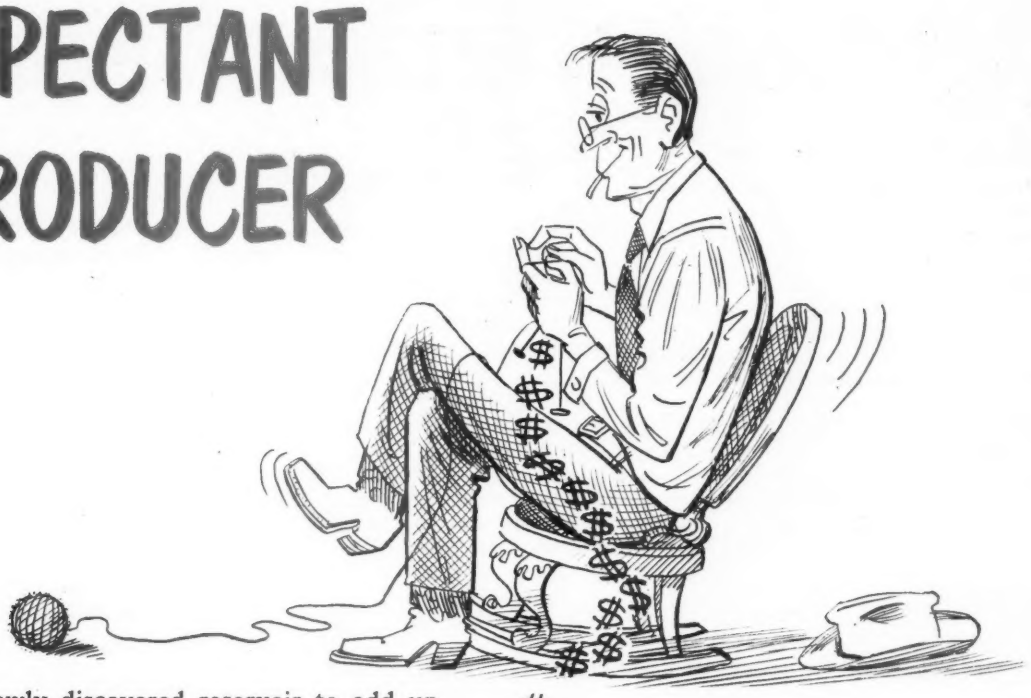
Alberta Well Shows Signs Of Good Oil Producer

A fourth Devonian formation discovery well has shown signs of a good well in Alberta. It is Superior Oil Company's No. 1 Norway. In the test gas and oil rose to the surface in a relatively short time, and Superior reported that "some oil was recovered." At latest reports, Superior Oil reported, operators are coring ahead.

New Wilcox Oil Field Opened in Mississippi

A new oil field has been opened in Adams County, Mississippi, at J. P. Evans et al's No. 1 A. K. Ellis. The well opens a new Wilcox oil field. On potential test, the well flowed at the rate of 132 bbl of oil per day through ⅛-in. choke. Gage was based on an actual 12-hr test during which the well flowed 66 bbl of oil. Gravity of oil is 37.8 deg. Tubing pressure was 560 lb and casing pressure 455 lb. The hole has been bottomed at 7109 ft, cased to 6620 ft, with 5½-in. pipe and has 2½-in. tubing swung at 6505 ft.

THE CASE OF THE EXPECTANT PRODUCER



Expecting his newly discovered reservoir to add up — barrel for barrel, dollar for dollar? Perhaps. But it's a long pull from bottom of the hole to the bank.

There's a lot more to learn about a reservoir, other than the fact that it is commercially productive.

The first step is to ask Core Lab to sample your key wells — *before pressure decline can alter basic productive characteristics* — and to perform a comprehensive analysis of the reservoir fluid. From these data, coupled with other knowledge of the formation, you can then learn how much of your proven reserves is actually producible; and how you can control that particular reservoir's natural productive tendencies with mechanical practices to effect maximum recovery.

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CORE LAB

PETROLEUM RESERVOIR ENGINEERING

Denver-Julesburg Well Opens New Oil Field

S. D. Johnson has opened a new oil field in the Denver-Julesburg Basin in Morgan County, Colorado, at its No. 1 Cnockaert. The wildcat swabbed 9 bbl of oil an hour, with a cutting of water, with pipe perforated in the "J" sand at 5862-64 ft.

Pakistan Surveyed by Air

Standard-Vacuum Oil Company has completed an aerial survey of many thousands of square miles in eastern Pakistan, the company has reported. A license has been granted Standard-Vacuum by the Pakistan government for oil exploration in that area.

Three good reasons for you buying a JENSEN

(1) ADAPTABLE—Jensen Pumping Units operate efficiently on the power that is most convenient and economical.

(2) VERSATILE—One man, in minutes, can balance any well easily, vary stroke lengths and pumping speeds, or change power and capacity.

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Kentucky Well Brought In

A new well has been brought in in Daviss County, Kentucky, swabbing six barrels of oil an hour naturally. The well is the J. C. Miller Oil-Ashland Oil and Refining Company's No. 1 Argyle Faith. Total depth of the well is 2118 ft. It is testing at 2017 to 2029 ft.

Arkansas Discovery Made

Stephens Production Company has a new Nacatoch discovery for South Arkansas. It is the company's No. A-1 C. & R. Wesson, which pumped 13 bbl of 13 gravity oil per day through open hole from 1364 to 73 ft. Crude is cut with 4 per cent basic sediment and water. Hole is bottomed at 1373 ft and pipe was cemented in open hole at 1364 ft.

Mid-West Opens Field

A new oil field has been opened in Runnels County, Texas, by Mid-West Oil Corporation. It is the company's No. 1 Ralph Burns, which is two miles west of the Jim Adams field. On completion test, the well flowed 216 bbl of oil in 19 hr through a ¼-in. choke, with gas-oil ratio of 658-to-1, from the Goens lime section at 4624-33 ft.

Light Oil Find in Canada

Canadian Southern Oil, Ltd., has made a light oil discovery in Saskatchewan, about 25 miles east of the Alberta Provincial boundary. The well, Canada Southern Oils No. 4 Driver, is about 5 miles west of the company's Coleville heavy crude oil field. It flowed 33 gravity oil on drillstem test with the oil reaching the surface in 32 min.

Argentina Oil Search Off

The Texas Company and Socony-Vacuum Oil Company have completed negotiations for their withdrawal from Argentina. Under the contemplated arrangement the properties of a commonly owned subsidiary well will be sold to the Peron government. Included are a refinery with a capacity of 6000 bbl daily, storage facilities of 2,000,000 bbl of petroleum products, and a tanker.

New Wyoming Area

A new oil discovery has been made in an unproductive area of Wyoming. It is McDermott and Company's exploratory well in north-central Seridan County, along the west side of the Powder River Basin. The well, which is 20 miles northwest of Seridan near the Wyoming - Montana boundary, made 1867 ft of 36 gravity oil on a 45-min drillstem test of the Shannon formation at 4714-4729 ft.

Gas Found in Nova Scotia

Geologists drilling salt and limestone deposits near Anaigonish have found natural gas for the first time in Nova Scotia, the Provincial Industry Department has reported. Dr. Don J. McNeil, geologist in charge of drilling operations for the department, found the gas about 400 ft down.

New Mexico Well Flows From Devonian Formation

The Texas Company has a Devonian discovery in Lea County, New Mexico. It is the No. 1 Moore, which logged 125 ft of Devonian pay. On the 4th drillstem test in that formation, from 10,451-475 ft, the wildcat flowed to pits for three minutes, then was turned to tanks for 2 hours, making 44 bbl of oil the first hour and 48 the second hour. Gravity ranged from 47.4 to 78 deg.

Texaco Gets Louisiana Well In Plaquemines Parish

Discovery well for a new oil field in Plaquemines Parish, Louisiana, has been completed by The Texas Company. It is the State Block 33-1, a mile from the nearest production. On a 24-hr potential test, the well flowed 133 bbl of 27.6 gravity oil daily, through casing perforations at 7849 to 7858 ft, a new depth for this area, through ⅛-in. choke. Tubing pressure was 800 psi and gas-oil ratio 616 to 1.

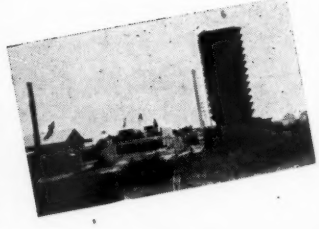
Phillips Drills Its First Williston Basin Producer

Phillips Petroleum Company has completed its first producing oil well in the Williston Basin, in Montana. It flowed 600 bbl a day from the Charles formation, according to Paul Endacott, president. The well is situated at East Poplar Dome federal unit in Montana.

SECONDARY MODERN RECOVERY
TECHNICAL CONSULTING PRODUCTION ENGINEERING SERVICE, INCLUDING CORE ANALYSIS

PRESSURE MAINTENANCE WITH GAS OR WATER

Presssure Maintenance and Gasoline Extraction Plant



JACK COUNTY, TEXAS

REPRESSURING WITH GAS OR WATER

SURVEYS
ESTIMATES
DESIGN
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PETROLEUM ENGINEERS
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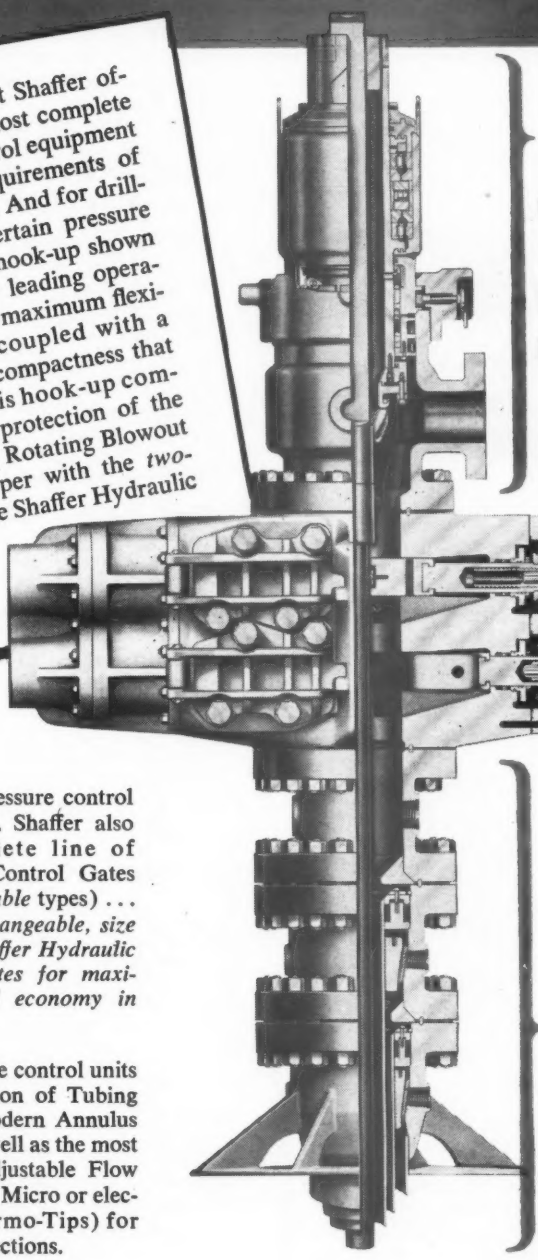
WICHITA FALLS, TEXAS

3 REASONS *why this Shaffer Hook-Up is the* Choice of Leading Operators!

It is a recognized fact that Shaffer offers the oil industry the most complete selection of pressure control equipment to meet the varying requirements of different field conditions. And for drilling under high or uncertain pressure conditions, the Shaffer hook-up shown at right is preferred by leading operators because it permits maximum flexibility of operation, coupled with a degree of safety and compactness that are unsurpassed. This hook-up combines the *automatic* protection of the Shaffer Combination Rotating Blowout Preventer and Stripper with the *two-way* protection of the Shaffer Hydraulic Double Cellar Control Gate . . .



1 ***THE SHAFFER COMBINATION ROTATING BLOWOUT PREVENTER AND STRIPPER*** **provides—*in one unit*—every necessary feature for successful and simplified pressure control while the drill string is in the hole . . .**

- **It *automatically* maintains a continuous seal around different shaped elements in the drill string — square, hexagon or round — regardless of whether the string is rotating, being raised, lowered, or is stationary.**
- **The seal *automatically* expands and contracts to fit the varying diameters of drill pipe, tool joints, couplings and drill collars.**
- **Bits, reamers and other abnormally large tools can be easily passed through the unit by merely turning the Quick Releasing Bonnet 1/6 turn and removing the sealing assembly. It's simple, quick!**

With no valves to open or close, nothing to remember, *nothing to forget* in the excitement of pressure emergencies, this unit gives *continuous* protection while the drill string is in the hole!

2 ***THE SHAFFER HYDRAULIC DOUBLE CELLAR CONTROL GATE*** **provides—*in one unit*—rams for shutting off the well when pipe is in the hole, as well as rams for sealing off open hole.**

- **Rams are opened and closed by *direct* hydraulic drive in a completely enclosed unit. No complicated yokes or secondary connections, no exposed moving parts to become wedged or damaged.**
- **Even in sizes as large as 13⅝" (12" Series 900) the complete unit, including *two* ram compartments, requires only 30" cellar height—smaller sizes even less!**
- **Rams can be easily changed—whether the pipe is in or out of the hole — by simply opening two doors in the side of the gate . . . the simplest, quickest ram changes in *any* gate!**

There are many other vital advancements—and the same basic features are also available in the Shaffer Hydraulic *Single* Cellar Control Gate, if this design desired.

3 ***SHAFFER LANDING AND CASING HEADS*** **are recognized throughout the industry for their rugged dependability and adaptability to various suspension and pack-off requirements. The bottom unit at left is a Shaffer Base Head from which two strings of casing are suspended and packed-off with maximum compactness . . . and in the Head above it a third string is suspended and packed off.**

With the casing program known in advance, the complete drilling and casing program can be completed without changing drilling connection, including gates, either in size or length during drilling of well.

Other types of Shaffer Heads and packing arrangements—including Shaffer Combination Base, Casing and Tubing Heads in *one unit*— are also available to meet virtually any well-completion requirement.

In addition to the pressure control units shown at right, Shaffer also provides a complete line of *Mechanical* Cellar Control Gates (both *Single* and *Double* types) . . . *and rams are interchangeable, size for size, between Shaffer Hydraulic and Mechanical Gates for maximum simplicity and economy in field operations.*

Other Shaffer pressure control units include a full selection of Tubing Heads (featuring modern Annulus Flange types) . . . as well as the most complete line of Adjustable Flow Beans (with Conical, Micro or electrically-heated Thermo-Tips) for use in the flow connections.

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See pages 4525 to 4600 of your 1951 Composite Catalog.

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Phillips Completes Deep Discovery in Texas County

Phillips Petroleum Company and associate are in the process of completing its new deep discovery well in Brazoria County, Texas Gulf Coast. The well, No. 1-A Houston Farms "R", is one and a half miles southeast of nearest production in the Chocolate Bayou field, and is producing from the deep Andrau sand zone. This sand zone is producing in the West Chocolate Bayou area five miles to the northwest, but has not heretofore been tested in the intervening area.

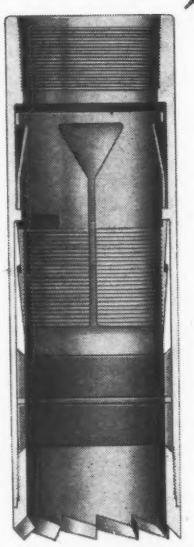
The pay zone encountered from 12,838 ft to 12,868 ft tested at the daily rate of 6,700,000 cu ft of gas and estimated 144 bbl of 38.8 gravity distillate, through a ¼-in. choke, from casing perforations 12,850-12,858 ft. The well will be perforated opposite the upper portion of the sand for further testing.

Sinclair Finds Oil In Oklahoma Well

Discovery of an important oil field has been announced by Sinclair Oil and Gas Company. The field is in Carter County, Oklahoma, and discovery well is Sinclair's No. 1 Brown, approximately 1½ miles northeast of Lone Grove. On drillstem tests in the Pennsylvanian sands, the well showed 4650 ft of 37.8 gravity oil at 5590-5625 ft, and flowed at a rate of 25 bbl of oil an hour from the 5624-74 acres.

THE PACKER TYPE
BOWEN RELEASING CASING BOWL
provides the economical, fast, safe way to repair defective casing

Packer Type Bowen Releasing Casing Bowls are used with great effectiveness in wells with casing difficulties. The standard procedure is to make a cut with an Internal Cutter in the casing immediately below the damaged area and to pull the casing from the hole. The damaged portion of the casing string is then replaced with good casing. A Packer Type Bowen Releasing Casing Bowl is then installed on the bottom end and lowered over the casing in the hole. When upward pull is exerted, the tapers on the Cone contracts the Slips into secure engagements with the casing and the Cone bears against and compresses the lead Packing into a leakproof seal around the casing.



DOES NOT REDUCE HOLE DIAMETER

The bore of this tool is always either the same or larger than the inside diameter of the casing on which it is to run, so that there is no impairment of any inside-the-casing operations.

OUTSTANDING RELEASE FEATURE

The releasing feature which is outstanding in the Packer Type Bowen Releasing Casing Bowl is very valuable. Should hole conditions prevent a perfect pack-off, the tool can be released and the casing again withdrawn without the expense of making an additional cut with an Internal Cutter. After the necessary corrections have been made, the tool can again be run in the hole and engaged with the casing. The releasing feature has been found to be advantageous in other instances where the operator has decided to abandon the well shortly after the tool was set because at practically no expense he can salvage the casing above the Packer Type Bowen Releasing Casing Bowl.

Release is effected by bumping down and rotating to the right. This hangs the Slip in its uppermost position. When in this position, the Slip cannot be contracted against the casing by the tapers on the Cone and the tool easily can be withdrawn.

Mill Type Guides and Oversize Guides are available for all Packer Type Bowen Releasing Casing Bowls. Mill Type Guides prove very advantageous in those instances where sand conditions necessitate washing-over operations. Oversize Guides insure alignment with the casing in large holes.

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Dual-Zone Well Completed on Montana Side of Williston

C. H. Murphy has completed a dual-zone discovery in the Montana portion of the Williston Basin. The well recovered a heavy flow of oil on a drillstem test at 5638-80 ft in the Charkes section of the Mississippian lime. At a lower zone, tentatively classified as the Mission Canyon member of Mississippian lime, the well also got flowing production. Test in the upper zone flowed 232 bbl of 40 gravity oil in 24 hr through 5/32-in. choke with tube pressure of 525 lb. The lower test in perforations from 5799 to 5814 ft brought 354 bbl of 40 gravity oil in 24 hr through ⅛-in. choke.

Manziel Well Completed In Smith County, Texas

Bobby Manziel has completed his No. 1 Will McGinnis for a new oil discovery in Smith County, Texas. The well is pumping at the rate of 24.75 bbl of 41 gravity oil per day from perforations in Pettitt at 8050-60 ft. Hole is bottomed at total depth of 8284 ft with 5½-in. casing cemented at 3961 ft and 4-in. production string at 8271 ft.

Mississippi Field Open

Gulf Oil Refining Company has uncovered a new producing formation in Wayne County, Southeastern Mississippi. Oil has been discovered in the Lower Cretaceous at the company's No. 1-A H. A. Chapman, Sr. The wildcat was originally drilled to the Salt at 14,296 ft, but has been plugged back to 9705 ft where the 5½-in. casing was cemented. In a test made at 9609 ft with perforations at 9590 to 96 ¼-in. top and ⅜-in. bottom hole chokes and using 1500 ft of water cushion. Flow was through 3/16-in. top choke.

Kentucky Oil Well Success

The Buchman-O'Neal and Aubrey-Tennant's No. 1 Bettie Moss has been brought in as a new oil well in Henderson County, Kentucky. The well has swabbed 36 bbl of oil an hour. It brought up oil from the McClosky limestone at 2427 to 2429 ft and 2464 to 2470 ft, after acidization.

Gulf Opens New Oil Field

Gulf Refining Company has opened a new deep oil field in Wayne County, Mississippi, at its No. A-1 Chapman. The well flowed at the rate of 494 bbl of 31 gravity oil a day through a 3/16-in. choke on initial test. Flow is from the lower Cretaceous zone, with pipe perforated at 9590 to 9608 ft. Total depth is 14,296 ft.

Skinner Sand Pool Open

A Skinner sand pool has been opened in Lincoln County, Oklahoma, by Gulf Oil Corporation at its No. 1 Henthorn Estate. Topping the Upper Skinner at 3995 ft and the lower Skinner at 4090 ft, a core at 4092 to 4102 ft recovered 10 ft of sand with good porosity, staining, and gas odor.

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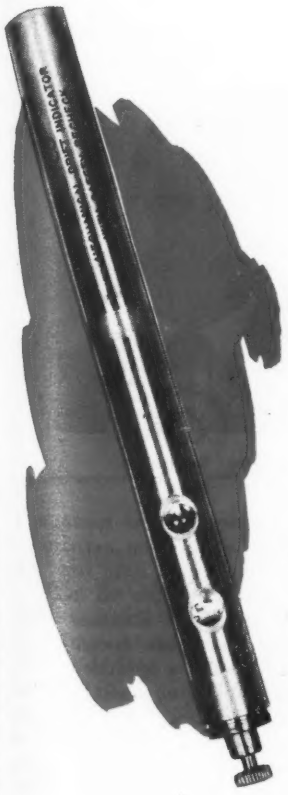
. . . EASTCO SELF-CHECKING MECHANICAL DRIFT INDICATOR

There are other drift indicators, but Eastman, and only Eastman makes one to DOUBLE CHECK itself (2 readings) with a 40-second interval between.

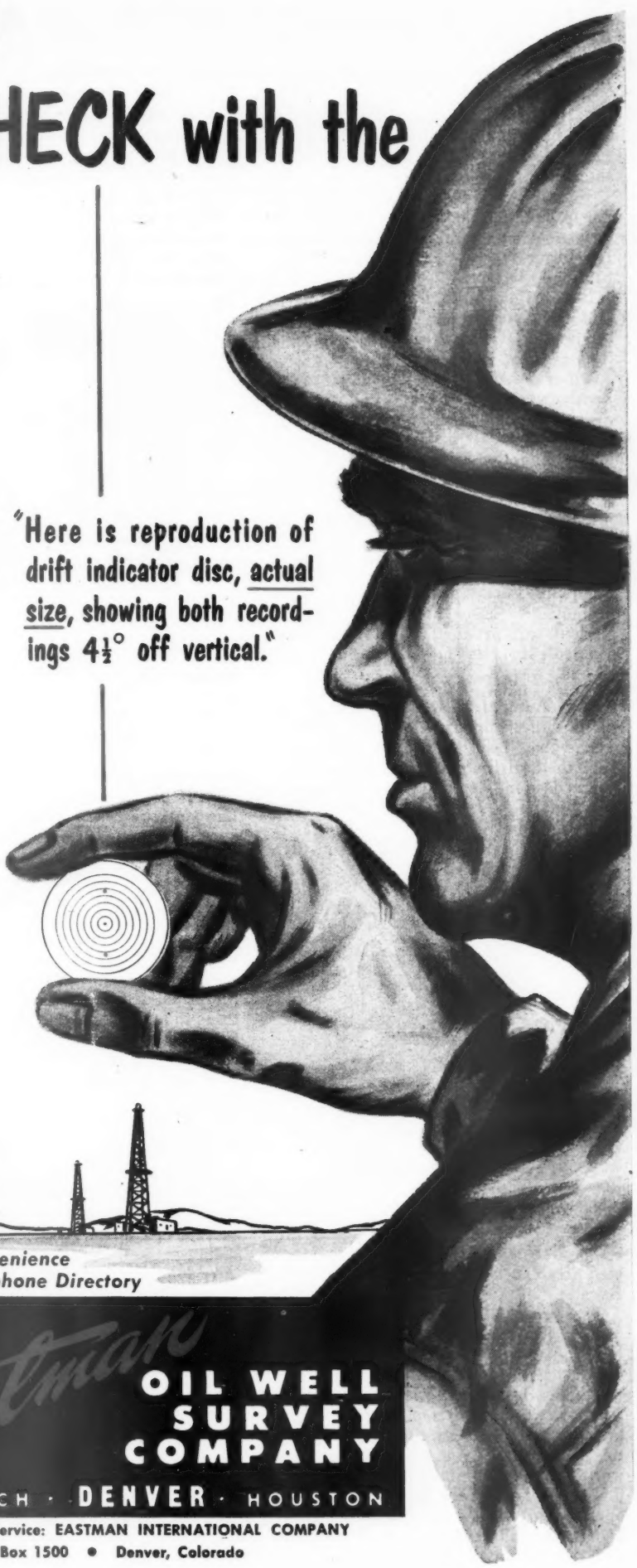
No batteries, light bulbs or photo sensitive discs are used. The Eastco Self-Checking Drift Indicator is COMPLETELY MECHANICAL.

This instrument is the smallest drift indicator on the market. It can be go-deviled or lowered into the hole on any conventional line.

Operators may contract for this instrument on a daily or term rental basis at a nominal charge. Call the nearest Eastman office for details and a demonstration.



EASTCO
Self-Checking Mechanical Drift Indicator



"Here is reproduction of drift indicator disc, actual size, showing both recordings 4½° off vertical."

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Running tour with men in the industry

A. J. Viets has been named regional land superintendent for Sun Oil Company. He formerly served as land superintendent for the Corpus Christi area.

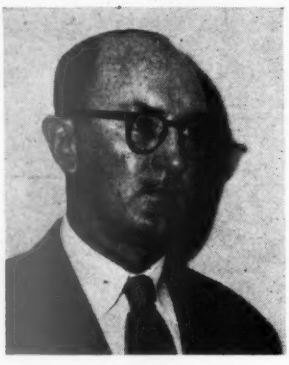
George P. Moncrief is the new assistant production field superintendent in charge of Sun's Premont, Texas, area. He formerly was district engineer at Midland, Texas.

Succeeding Moncrief at Midland is **D. C. Brown,** formerly field engineer for the Snyder, Texas, area. **C. E. Rogers** is the new field engineer at Snyder.

Other personnel changes included appointment of **Ray Bray** of Midland as district landman at Tallahassee, Florida; **G. M. Adair** of LaGrange as landman at Jackson, Mississippi; **H. T. Teel** of Premont as foreman at Victoria, and **J. W. Metcalf** of Longview, Texas, as foreman in that area.

J. R. Chestnolvick, former area production engineer for Continental Oil Company, Fort Worth, Texas, has been promoted to assistant district superintendent of production, Hobbs, New Mexico. He has moved his office to Hobbs.

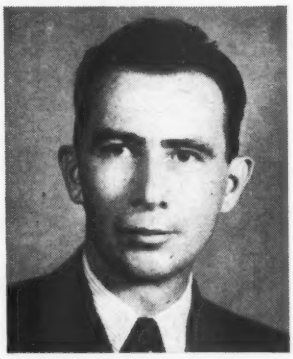
E. C. Taber, Jr., division geologist for Shell Oil Company at Wichita Falls, Texas, has been moved to Oklahoma City to head that division, and will be succeeded in North Texas by **George H. Thompson, Jr.,** who has been assistant division geologist in Colorado. Taber has been with Shell since July, 1939.



W. A. Gorman

W. A. Gorman has been appointed vice president and chief geologist of the Rycade Oil Corporation of Houston, Texas. Prior to joining Rycade in March, Gorman served as manager of the Houston division of Royal Oil and Gas Corporation for 10 years. He received his BA and PhD degrees from the University of Minnesota. Shortly after finishing school, he went to Africa where he spent three years in exploration work for copper mines. As a result of this work, four of the mines are still in operation. He is a member of the AAPG and Houston Geological Society, and listed in *American Men of Science.*

J. N. (Sandy) King, Jr., has resigned his position as senior staff geologist with Mid-Continent Petroleum Corporation of Tulsa, Oklahoma, to set up offices as an exploration consultant. He will do a limited amount of general consulting work, his primary interest being in acquiring drillable acreage, negotiating farm-outs, etc.



J. P. Malott

J. P. Malott, Houston, Texas, has been promoted to assistant manager of Continental Oil Company's production department. Malott, who was formerly southern regional production manager, will make his headquarters in Houston, succeeding **H. H. Hinson,** recently promoted to general manager of Conoco's new southwestern region, Fort Worth.

Malott joined Continental 17 years ago, soon after his graduation from New Mexico School of Mines, Socorro.

R. Lee Hunter has been appointed to the newly created position of director of geological training for Continental Oil Company, it has been announced by L. F. Athy, manager of Continental's exploration department. Hunter will continue to make his headquarters in Ponca City, Oklahoma, and to supervise the company's core drilling operations.

Hunter has been associated with Continental since 1936, and is a graduate of the University of Oklahoma, Norman.

James E. Keenan has been appointed assistant supervisor of exploration for the Rocky Mountain division of General Petroleum Corporation. **C. E. Carlson** succeeds Keenan as district geologist for Montana, with headquarters in Billings, Montana. Keenan will be stationed in Casper, Wyoming.

Keenan joined General Petroleum in 1946 after four years with Magnolia Petroleum Company, with which General Petroleum is affiliated. He will report in his new position to K. A. Gorton, supervisor of exploration for Rocky Mountain division. He is a graduate of the University of Missouri, having received his master's degree in geology there. Carlson came to General Petroleum in 1949 after receiving his master's degree in geology from the University of Wyoming.

G. C. MacDonald, chief drilling engineer of Gulf Oil Corporation, Tulsa, Oklahoma, has been named chairman of the Mid-Continent district, API division of Production. He replaces **Harold E. Berg,** also of Tulsa, division superintendent for Oklahoma, Kansas, and North Texas for Tide Water Associated Oil Company.

Also named were **Herbert M. Cooley,** Tulsa, Bethlehem Supply Company, secretary-treasurer; **Fred Neslage,** Pampa, Texas, West Pampa Repressuring Association, vice chairman for the Texas Panhandle; **Berdun Leonard,** Duncan, Oklahoma, Magnolia Petroleum Company, vice chairman for Southwestern Oklahoma; **S. K. Myers,** Great Bend, Kansas, Atlantic Refining Company, vice chairman for Western Kansas; **A. H. Massard,** Drumright, Magnolia Petroleum Company, vice chairman for Northeastern Oklahoma, and **Jack L. Worley,** Wichita, Independent Oil and Gas Service, vice chairman for Eastern Kansas.

James S. Royds has been named head of Rocky Mountain exploration activities by Continental Oil Company. He succeeds **K. W. Brill,** who recently was promoted to assistant manager for the southern division of Continental. **W. G. Olson,** division geologist at Casper, Wyoming, will take over the regional post in Denver, Colorado. He is succeeded by **E. C. Mees.**

Oscar L. Keesee

Oscar L. Keesee is new manager of Midstates Oil Corporation activities in Oklahoma. Keesee is a long time resident of the state but his oil activities have carried him into Kansas, Texas, New Mexico, and more recently into Canada and the states included in the Julesburg and Williston basins. He has been associated with Shell Oil Company, Magnolia Petroleum Company, and Superior Oil Company of California. Keesee assumes charge of Midstates' recently enlarged headquarters in the new Liberty Bank Building in Oklahoma City where the company has recently consolidated all land, geological, and scouting activity for the state.

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2. 13,211 feet	Mechanical Long Knife Internal Cutter. Size: 2¼", run in on 1¼" tubing. Three cuts made, the lowest one at 13,211 feet.	Ventura, California
3. 13,005 feet	5" Jet Casing Cutter.18# N-80 casing. Temperature over 277°F. 13,005 feet of casing recovered.	Casper, Wyoming
4. 12,500 feet	Bullet Type Gun Perforator (Burrless Bullets). One string of cemented casing—5½". 1560 B/D potential.	Hobbs, New Mexico
5. 12,492 feet	Radiation Well Logger and Bullet Type Gun Perforator (Burrless Bullets). One string of 6⅝" 32# casing. Engineers reported a very good well, production not released.	New Iberia, Louisiana
6. 12,265 feet	Glass Jet Perforator with Steel Strip Carrier. One string of 5½" cemented casing. 3100 B/D.	Odessa, Texas
7. 11,495 feet	Bottom Hole Jet Cutter. Temperature 280°F. Eliminated junk in bottom of the well.	Bakersfield, California
8. 10,200 feet	10¾" Jet Casing Cutter. 51# N-80 cemented casing. 10,200 feet of casing recovered.	Casper, Wyoming
9. 10,000 feet	Magna-Tector and String Shot Back-Off. Stuck drill pipe recovered without damage.	Ventura, California

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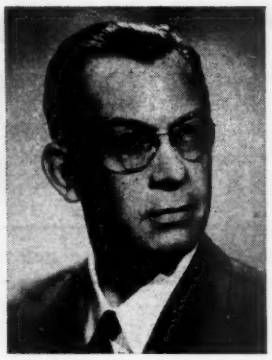
To obtain more information on products advertised see page E-49

Running Tour

W. A. Wilson



A. J. Olson

Courtney J. Berlin

W. A. (Bill) Wilson has succeeded Earl Rees as the president of the Los Angeles Chapter of Nomads upon the latter's transfer to New York. Bill is vice president of Web Wilson Oil Tools, Inc., and president of the Atlas Heat Treating Corporation. After graduation from Stanford in 1936 he worked with Web Wilson Oil Tools, Inc., until he entered the Army Ordnance Corps with which he served for 3½ years.

A. J. Olson, past president of the Dallas-Fort Worth Chapter of Nomads, has been elected to the chairmanship of the National Board of Regents, Nomads for 1952. After graduating from Iowa State College with a BS degree in mechanical engineering, Olson went to work for Fairbanks-Morse in Chicago, and in 1927 became machinery sales engineer for Continental Supply Company. At present he is chief engineer of Continental, with offices in Dallas.

Courtney J. Berlin has been elected secretary and treasurer of the National Board of Regents. A graduate of the University of Michigan, Berlin went to work for the Ohio Oil Company. In 1941 he became a sales engineer for Baker Oil Tools, Inc., and is presently division sales engineer with that company, with offices in Dallas.

A. H. Massad, formerly district petroleum engineer of Magnolia Petroleum Company's Wewoka, Oklahoma, district, was transferred to Cushing producing district with headquarters at Drumright.

A. J. Monzingo, who has been a petroleum engineer in the West Texas division offices at Midland, has been moved to the Wewoka producing district and promoted to district petroleum engineer.

John L. Moye, petroleum engineer in the Rodessa producing district, has been transferred to the Shreveport, Louisiana, division offices.

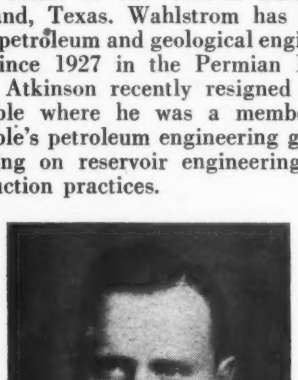
L. N. Halstead, petroleum engineer in the Duncan, Oklahoma, producing district, has been transferred to Magnolia's Electra, Texas, district.

Glen W. Barb, formerly petroleum engineer at Vanderbilt, has been moved to the Duncan producing district. **Cecil M. Rhodes** has been promoted from marine foreman to production foreman in Magnolia's Louisiana-Gulf division. This division has charge of Magnolia's offshore drilling operations.

Travis H. Bryant has been promoted from driller to drilling tools foreman in the Gulf Coast drilling division.

Asa D. McRae has been promoted from geologist at Lake Charles, Louisiana, to district geologist in charge of Magnolia's Illinois district with headquarters at Mount Vernon. **Charles A. Miller,** petroleum engineering assistant in the Kermit, Texas, producing district, and **J. E. Middleton,** petroleum engineer in the Falfurrias district, have been transferred to the producing division and made assistant foremen.

E. A. Wahlstrom and **Burton Atkinson,** petroleum consultants have moved their offices to the Central Building, Midland, Texas. Wahlstrom has practiced petroleum and geological engineering since 1927 in the Permian Basin area. Atkinson recently resigned from Humble where he was a member of Humble's petroleum engineering group, working on reservoir engineering and production practices.



Eddie Durette

Eddie Durette has been named drilling superintendent for the West Texas Division of Delta Gulf Drilling Company. Delta Gulf operates heavy duty rotary rigs widely scattered throughout West Texas and the Gulf Coast. The company maintains general offices at Tyler, Texas, and branch offices at Odessa, Dallas, and Houston, Texas, and Lake Charles, Louisiana. Durette, formerly a student in the petroleum engineering school at Texas A & M and the business administration school of the University of Houston, has had many years of rotary drilling experience in the Gulf Coast and in West Texas with Loffland Brothers Company.

Bruno R. Schabarum has been elected to the presidency of Carl B. King Drilling Company replacing **J. Ed Warren** who has been called to Washington to assume the duties of deputy administrator of the Petroleum Administration for Defense.

Schabarum is former director of the American Association of Oilwell Drilling Contractors, chairman of the Southwestern District of Production of American Petroleum Institute, and technical advisor of Drilling Research, Inc. He resigned his position as assistant to the president of National Supply Company in 1944 to become an engineering executive of the Carl B. King Drilling Company. He was advanced to the post of general manager in 1949.

Bruno R. Schabarum

Schabarum announces the promotion of **C. J. "Dutch" Jensen,** drilling superintendent, to the office of vice president and the appointment of accountant-office manager **H. Don Johnson,** to the post of secretary-treasurer.

Jensen resigned his position with Noble Drilling Company as drilling superintendent in charge of a six state area in 1943 to come with Carl B. King and later was promoted to drilling superintendent of the company. He has appointed **Jack Forgerson,** who was his assistant, to the post of drilling superintendent.

H. Don Johnson, active in oil field accounting since 1932 has run the accounting department and office management of King Drilling since 1943.

Joe F. Homer, assistant division petroleum engineer in the Humble Oil and Refining Company's Louisiana division, has been promoted to assistant district superintendent of the Grand Isle district.

Philip S. Weathers, senior clerical supervisor in the policy and organization division in Houston, Texas, has been made assistant policy and organization co-ordinator. **Charles D. East,** senior division clerk for Humble's Southwest Texas division office in Corpus Christi, was transferred to Houston to become senior clerical supervisor. Replacing East in Corpus Christi is **F. P. Beall,** formerly assistant district chief clerk at Kelsey district in Southwest Texas. **Sherman J. Glass,** division clerk for the Gulf Coast division with headquarters in Houston, was transferred to the policy and organization division as clerical supervisor.

Paul D. Balbin

Albert D. Dunlap

Paul D. Balbin has been named to head Stanolind Oil and Gas Company's geophysical operations in the North Texas-New Mexico Division. Division headquarters are in Fort Worth, Texas. Balbin was formerly geophysical supervisor in Stanolind's Tulsa general office, and is being transferred to Fort Worth due to the expanded geophysical activities in that division. Under the company's decentralization program, active responsibility for all geophysical field work is centered in the different division offices.

Balbin received his BS degree from the University of Oklahoma in 1933, and joined Geophysical Research Corporation following graduation. In November of 1936, he was employed by Western Geophysical Company, transferring to Stanolind in 1938. He is a recent graduate of the Advanced Management Program at Harvard University, having completed the fall session in December, 1951.

L. C. Bellis has joined Petroleum Consultants, Houston, Texas, as a petroleum engineer. Bellis was graduated from Texas A & M in chemical engineering in 1946, and later did graduate work at the University of Texas. Later he was with Socony-Vacuum Oil Company as a field petroleum engineer in various parts of Venezuela.

Following this Bellis worked with Texas Gulf Producing Company as field engineer. Until recently he was on the staff of the Seeligson Engineering Committee, San Antonio, as reservoir engineer. He served in the U. S. Army as first lieutenant from 1943-46.

Dr. Sherman A. Wengerd, associate professor of geology at the University of New Mexico, has been appointed Editor of the Four Corners Geologic Society Symposum to be published in the late summer or early fall of 1952. The symposium will cover the geology of oil and gas fields; regional geology, stratigraphy, structure, and exploration in the vast Four Corners region. The symposium will have 24 contributors who are company and independent geologists active in the search for oil and gas in the area. Publisher of the symposium will be Case-Thompson of Albuquerque, and pre-publication orders will be announced by July 1 by Silas Brown, president of the Four Corners Society in Durango, Colorado.

Albert D. Dunlap has recently been promoted to supervise all Canadian operations with headquarters in Calgary, Alberta, Canada, for Independent Exploration Company. Dunlap was graduated from Rice Institute in Houston, Texas, and was first employed by Independent Exploration in September of 1933, beginning as a helper. He has worked on every job in the seismograph exploration party and was for some years prior to his recent promotion, a party chief.

John T. Galey, independent producer, Pittsburgh, has been elected chairman of the Eastern district, American Petroleum Institute, Division of Production. District chairmen include: **Paul G. Benedum,** Hiawatha Oil Company, Pittsburgh, vice chairman; **R. L. Bird, Jr.,** Columbian Carbon Company, Charleston, West Virginia; **Harry Brown,** Chartiers Oil Company, Pittsburgh; **Jack Cashell,** Preston Oil Company, Columbus, Ohio; **Vance Orr,** Roosevelt Oil and Refining Company, Mt. Pleasant, Michigan; **T. C. Stauffer,** Sun Oil Company, Evansville, Indiana; and **Sam S. Taylor,** U. S. Bureau of Mines, Franklin, Pennsylvania.

The new secretary-treasurer is **John Buckwalter,** Ryder-Scott Company, Bradford, Pennsylvania, and **Edward T. Heck,** retiring chairman also of Bradford, was named chairman of the advisory committee.

Dr. Frank A. Melton, University of Oklahoma, has been granted the Talbert Abrams award by the American Society of Photogrammetry, for a paper published in the society's bulletin last September. Dr. Melton pioneered aerial photography in geological work.

The three principal newly elected officers of the American Society of Photogrammetry are **George D. Whitmore,** president; **Alfred O. Quinn,** vice president; and **Ford Bartlett,** second vice president.

Duane C. Randall has been appointed senior geologist in the Chase National Bank, New York City, petroleum department.

In the foreign field, Randall was employed by Creole Petroleum Corporation, from 1944 to 1948, as district geologist in the San Joaquin-El Roble fields in eastern Venezuela and later as the company's budget coordinator.

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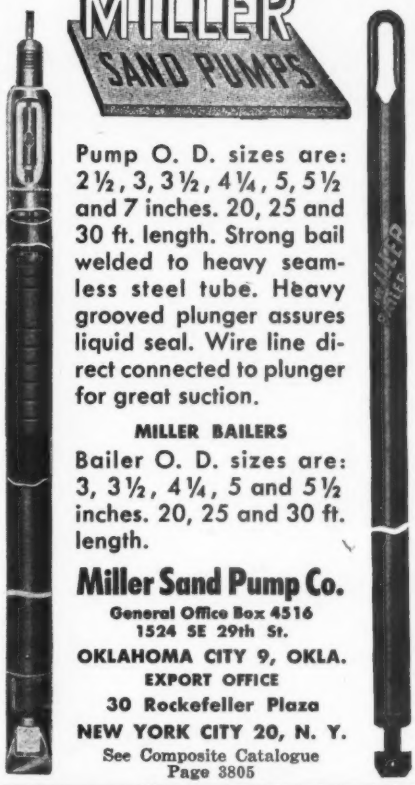

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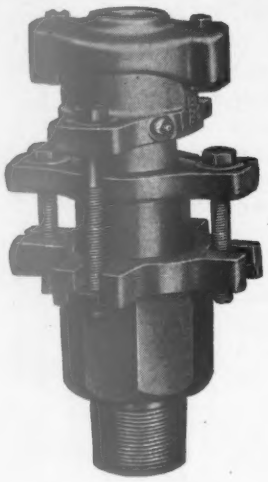

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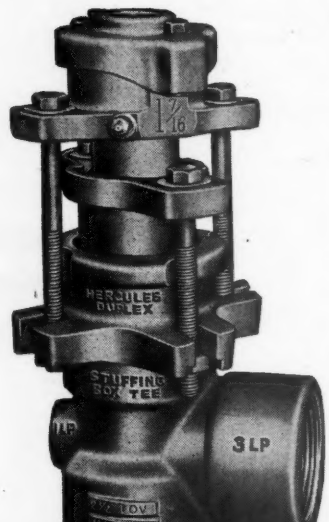

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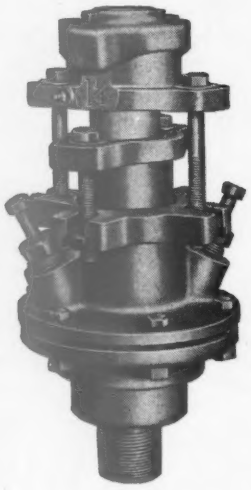

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Running Tour

J. Nelson Mendenhall has been named general manager of the domestic crude oil production department of The Atlantic Refining Company. Several other executive promotions in Atlantic's production organization in the Southwest have also been effected.

Carle F. Sharp will succeed Mendenhall as manager of the land division; **W. Dow Hamm** has been appointed general manager of exploration, which includes both domestic and foreign operations; and **Edgar Kraus**, chief geologist, is named manager of domestic exploration.

Mendenhall has been with Atlantic since 1919 as a member of the land division, and has been manager since 1925. Sharp joined the company in 1926 as an engineer, and was made assistant to the manager of the land division in 1937. Hamm became associated with the company in 1942 as manager of domestic exploration, and Kraus, who joined Atlantic in 1921 as a geologist, became chief geologist in 1946.

L. V. Nugent has joined Kirkpatrick and McGuire, consulting petroleum engineers, Shreveport, Louisiana, as field superintendent, with headquarters at Chanute, Kansas.

Nugent has been affiliated with the oil and gas business for 29 years. He worked for 17 years for the Blackwell Oil and Gas Company of Cushing, Oklahoma, working in gasoline plants, then as roustabout, advancing to superintendent.

Following this he was employed by the Haynesville operators committee in 1946 as field superintendent.

Immediately prior to joining Kirkpatrick and McGuire he was associated with Butler Johnson Service Corporation as toolpusher.

Harris H. Allen has been named manager of Phillips Petroleum Company's land and geological department of the Houston district. He was a former geologist. **T. E. LeRoy** has been transferred from Lafayette, Louisiana, to Houston to become district geologist. **S. K. Childers**, Wichita Falls, Texas, has been moved to Houston as district land man there.

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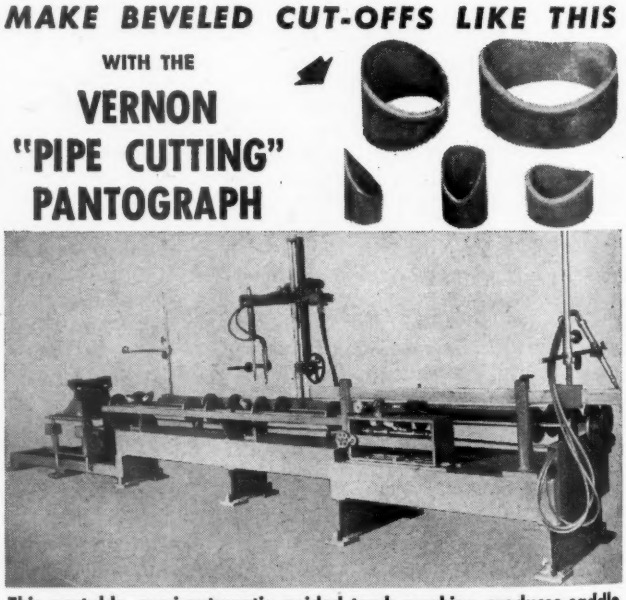

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Can Private Business Compete With Government?

Western Petroleum Refiners learn the handicaps forced on individual enterprise—and hear of vast strides in technology

ARCH L. FOSTER*

IT is a losing proposition for private industry to attempt to compete with the Federal Government in the production of "goods and services" for the American people, and for those customers outside the U. S. who look to us for these commodities. That is what John B. Thomas, president and general manager of Texas Electric Service Company of Fort Worth, told the assembled refiners at the Western Petroleum Refiners Association in San Antonio on April 1.

Thomas summarized the encroachment of Federal agencies on the domain of private Big Business during the present socialistic regime in Washington; the production of water power, hydroelectric plants, and dams for supplying business and the population in general with power produced in units paid for by taxpayers' dollars, competing with private companies, which must supply their own capital, make a profit, and make up any deficits. These private companies must pay their way, must meet other private competition, pay current wage rates, make up deficits, and show profits on invested capital; none of these handicaps are faced by Government agencies; taxpayers pay the deficits, ask for no profits and supply capital and additional capital.

Similarly Federal agencies are trying to get into the petroleum and coal industries, via the synthetic fuels route, for example, and the effort goes on and on, throttling the efforts of business that pays the taxes to build units to compete against itself. By implication, this effort reduces the amounts of taxes which private business can pay, destroying further any private initiative. Continuing this trend to its logical climax means the reduction of everything to the socialist state, which becomes the police state. Further evidence of the Government's effort to take over the oil industry is seen in the Tidelands battle, still being fought in the Congress.

In spite of these ominous signs of the times the refiners gave careful attention to manufacturing technology, and to economics in its three-day conclave at San Antonio. Economics, refining costs, and the technology of catalysis and of catalytic reforming held the attention of the nearly 1000 men registered at this meeting, the largest in the association's 40-year history.

*Editor, Refining and Gas Processing.

Coking Process

The general consensus has been among refiners that, in a region where large demand for residual fuel oil exists, no advantage is gained by adopting the coking procedure for conversion of heavy oil to light products and coke, say R. T. Colquette and C. W. Peters of Pan-Am Southern Corporation. This company some time ago adopted the process of delayed coking not so much to reduce the production of heavy fuel oil but to increase the total yield of light products from a given volume of crude, since the company's major market demand is for gasoline and distillate fuels and its crude supply limited.

Developing the economics of additional gasoline production can be done by two alternatives, coking of heavy residues and topping-cracking more crude, based on processing 30,000 bbl per day of crude in each case. When disposing of 25 per cent of the charged crude as No. 6 fuel oil, the yield of straight run and cracked gasoline is 14,500 bbl, total fuel oil 8500 bbl, and 1200 bbl fuel-oil-equivalent (FOE) of the fixed gas made. In each of three cases 6000 bbl of distillate fuel is produced. Processing the same amount of crude, 30,000 bbl per day, but coking the reduced crude to yield more gasoline, and solid coke (290 tons per day) yields of 19,150 bbl of gasoline and only 1800 bbl of heavy fuel are obtained, with 2300 bbl FOE of gas made.

At current prices the gross profit for coking operations above crude processing is $3,555,000 annually. Even after deducting current Federal income tax on that sum, 52 per cent, the net profit is $1,900,000, which amortizes or pays out the additional cost, coking facilities, in three years.

One obvious commentary on the advantage of coking, under the conditions outlined earlier, is that several new units are being built to coke heavy residuals including one for Shamrock at Sunray, Texas, a second for Pan-Am Southern, this at Destrahan, Louisiana, and one for Continental Oil Company, a 12,000-bbl

J. B. Thomas, president and general manager, Texas Electric Service Company (with cigar) receiving congratulations of members attending the WPRA meeting Tuesday, April 1, for his outstanding presentation of the subject of government in business and its implications for free enterprise and private business. At his right is R. L. Tollett, Cosden Oil Corporation, reelected president of WPRA.

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per day unit. These last units are designed on the new continuous coking process by Lummus Company.

The economic story for coking, these authors emphasize, is different for each situation. Each problem is different; product prices, capital availability, crude supply and many other factors must be evaluated. With increasing demand for light oils and potential crude shortage the coking process will assume greater importance in the future refiner's bag of tricks.

Importance of Catalysts

The catalyst is the overall important factor in catalytic reforming, say B. E. Milner, M. J. Fowle, R. D. Bent, and G. P. Masilogites of Atlantic Refining Company, in discussing the discoveries made in their research for a more useful catalyst for this process. The Atlantic Catalytic Reforming Process is available in units of 750 to 12,000 bbl per day naphtha charge capacity; initial investment cost ranges from $350 to $450 per daily barrel of naphtha charge, these authors stated. The catalyst employed now is the result of extensive research to make a catalyst that shows long activity life with high conversion rates, the discussion indicated.

After 30 bbl of product per pound the catalyst still shows a satisfactory activity; currently it is understood that calculations are made on this basis. High yields are obtained from naphthas of various sources; from a high aromatic crude (Tucupido) treatment of naphtha showed a 94 per cent yield of reformate of 83.5 clear Research octane number. The presence of water does not deactivate this catalyst; also, the presence of arsenic to the extent of "10,000 parts per billion" showed no ill effects on the catalyst, although arsenic is a serious catalyst poison in most cases. The catalyst is not regenerated in normal operation, but, if for any reason an excess of carbon is deposited, it can be burned off successfully without catalyst damage. Customarily the catalyst, after several months of operation is returned to the catalyst maker for chemical reconstitution, the authors stated.

Cost Control

The primary advantage resulting from careful cost analysis and a thorough system of cost accounting must be that of cost control, wrote the late Emory M. Skinner, of Socony-Vacuum Oil Company, discussing the role of cost accounting in refining. Emory Skinner died suddenly in February of a heart attack, just after completing his paper, which was presented by R. R. Erwin, general manager of Socony-Vacuum's White Eagle Division. "(Cost) control must result from the action taken by an informed management. The compilation of data is of no avail if an effort is not made to interpret that data in terms of physical activities and to search for improved methods of conducting the activity in question". The largest single

H. D. Noll, Houdry Process Corporation, left, presenting paper on Houdriforming, co-authored with T. A. Burtis, before the Western Petroleum Refiners Association, in San Antonio, Texas, April 2; at right is C. C. Tate, vice president, Phillips Petroleum Company, presiding.

item of expense (in refining) are labor and fuel burned, Skinner said. The greatest contributors to an excess of these costs are poor facilities and incorrect manipulation. An informed supervisory and technological staff, armed with the authority to act, carries the responsibility for improved results.

Evaluation of a refinery cost problem breaks down into *six* major steps, the author outlined. These are:

Tabulate a material balance, the details of which depend on the nature of the operation under study;

Establish the required operating schedule for the operation—each process, including turnaround time, methods of operating units, and any "blocked" operations required;

Develop realistic expenses for each operation;

Develop input cost and production value by pricing all petroleum commodities at current prices;

Determine a statistical profit from these elements.

Make this evaluation for the normal plant operation, and for any modified operation. The difference in profitability "must be reflected upon the modification under study". In other words, the difference in net profit must pay for the costs of the changes in process or operation required to permit the new operation to go forward.

Octane Advance

Postwar, the average volatility of motor fuels has increased at a slower rate than was the case before and during the war (II), according to R. C. Alden, H. J. Elder, and Elizabeth Aldrich of Phillips Petroleum Company. This situation is traceable to the differences in refinery processing, introduction of catalytic cracking, reforming and other processes affecting octane number and volatility of motor fuel components. Prewar, when octane numbers were upped it was accomplished essentially by increasing the amount of light ends, and decreasing the heavy ends fractions, each contributing to the rise in volatility with rise in octane ratings.

In postwar motor fuels, a slackening of volatility increase is shown; in fact the trend toward decreasing heavy ends percentages has been reversed, especially in premium gasolines. The average Gulf Coast regular summer gasoline indicates a decrease in incipient vapor lock temperature of about 15 F. Due to these changes our present summer gasolines are more volatile than 1937 winter gasolines, Alden and collaborators point out. This results in a vapor lock temperature for 1951 summer gasoline some 4 F lower than for a 1937 winter gasoline.

The conflict between carburetor icing and acceleration performance cannot be reconciled by volatility changes, it is stated, since the volatility changes required for an appreciable improvement in carburetor icing would impair seriously the acceleration performance of the fuel, especially during warmup periods. The mutually incompatible requirements of freedom from vapor lock and of easy starting make a compromise difficult but it is fairly well attained by careful adjustments in volatility, especially for the transition periods taking up about half the year—fall and spring. The trend toward greater volatility gives greater flexibility in refinery operations, also better fuel performance in its most important phases.

Reforming Process

Catalytic reforming has a strong place in the operations of the refinery under present conditions, according to the report by T. A. Burtis and H. D. Noll of Houdry Process Corporation, discussing the advantages of Houdriforming (see entire paper elsewhere in this issue). The authors presented four specific cases in refining and showed yields, properties and financial returns for each, to show how catalytic reforming can be used profitably to upgrade products and increase monetary returns to the refiner.

* * *

Investigations With Gas Density Balance

PART 1—THE PRINCIPLE AND THE METHODS OF USE

J. H. SILBERBERG[1] AND JOHN J. McKETTA, JR.[2]

Abstract

Contrary to popular opinion the gas density balance method may be used for precise research work. The compressibility factors of gases may be obtained directly. The molecular weight of gases may be obtained by indirect means.

This paper covers three items: (a) the principle of the balance, (b) three methods of using the balance for experimental work, and (c) the use of air as a standard gas.

Part 2 includes the experimental results on the low pressure compressibility factors for methane, ethane, propane and n-butane.

APPROXIMATELY 35 years ago, Junius D. Edwards introduced to American engineers a balance for the measurement of the specific gravities of gases. In an early article, Edwards[8] described the principle of the balance and the construction of both a glass balance and a metal balance. In a somewhat later publication, he compared the "specific gravity balance" with other methods of determining gas gravities and stated that the balance was capable of producing results accurate to about 0.2 per cent.[9] From this rather inauspicious beginning, the "specific gravity balance" or gas density balance has risen to a position of considerable importance in the field of gas specific gravities and low-pressure compressibilities and in atomic weight determinations.

At the present time, several companies manufacture gas density balances and sell them for moderate prices. These balances vary in size and in certain other minor aspects, but basically they all operate on the same principle. They are of primarily metallic construction, thereby effecting the combination of accuracy and sturdiness. Some are water-jacketed for temperature control, and some may be made portable for field as well as for laboratory use. Smith, Eiseman, and Creitz[16] tested several of these balances and found that all gave creditable performances.

A more fragile but generally more accurate type of balance may be constructed entirely of quartz or glass and may be enclosed in either a glass or metal case. Such a balance was used by Stock and Ritter[18] in their investigation of the variation in the normal density of atmospheric air and later by Stock, Ramser, and Eyber[17] in their work on the same problem. Cawood and Patterson[7] used a quartz microbalance to determine the atomic weights of carbon, nitrogen, and fluorine, and cited instances in which this type of balance had been used to determine the atomic weight of radium emanations, to determine the density of hydrogen, and to test the partial separation of isotopes of neon by diffusion and by refractionation. Massie and Whytlaw-Gray[14] used a quartz microbalance to determine the normal density and expansion coefficients of propane. Casado, Massie, and Whytlaw-Gray determined the molecular weight and gas compressibility of propane[5] and of benzene[4] by means of a similar balance. The accuracy achieved in these investigations has demonstrated that the gas density balance is capable of far greater accuracy than was predicted originally by Edwards.

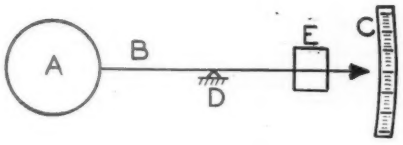

FIG. 1. Gas density balance mechanism.

Principle of the Balance

The familiar principle of Archimedes states that a body immersed in a fluid medium is buoyed by a force proportional to the mass of the medium displaced by that body. Consequently, if a body of a fixed volume is completely immersed successively in two different fluids, the difference in the extents to which the two fluids buoy the body is a measure of the difference in the densities of the two fluids. It similarly follows, that, if the body is buoyed to identically the same extent by the two fluids, these two fluids must possess exactly equal densities. The gas density balance represents such a situation, for it determines the temperatures and pressures of two gases such that their densities are equal.

The working mechanism of a gas density balance is shown schematically in Fig. 1. A sealed float (A in Fig. 1) of a light but rigid construction is attached to the end of the rigid beam (B). At the opposite end of the beam is a pointer, and, adjacent to the pointer but supported independently of the beam, is a calibrated scale (C). The beam is supported from a horizontal fulcrum (D) such that the beam is free to oscillate in a vertical plane about the fulcrum. Some provision is made to load the beam to varying extents; this may be indicated by a movable counterweight (E) on the beam. The mechanism shown in Fig. 1 is enclosed in a leak-proof case. The case is equipped with a window or equivalent device to permit observation of the position of the pointer relative to the scale and with suitable outlets to permit the entry and removal of the gas. Also, a provision is made for the determination of the temperature and pressure within the case.

In operation, the case is evacuated and then charged with an experimental gas until the pressure is such that the pointer indicates a certain scale reading, generally that which corresponds to a horizontal position of the beam. This pressure and the temperature within the balance case are the balancing pressure and temperature of that particular gas. The process is repeated with a standard or reference gas, the pressure being adjusted so that the scale reading is identical to that with the experimental gas. In this manner, the pressure and temperature are determined that characterize for the standard gas the same density as that possessed by the experimental gas at its observed temperature and pressure. In other words, a set of equal-density conditions are determined for the two gases. Generally, the balancing temperatures of the two gases should be kept as close as possible to prevent thermal changes in the volume of the float and the length of the beam. A change in the setting of the counterweight will permit a repetition of the procedure, resulting in a dif-

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ferent set of equal-density conditions for the two gases.

The ideal gas law equation, modified by the insertion of the compressibility factor z, is written as

$$pV_n = znRT = z\frac{m}{M}RT = \frac{zmRT}{M} \quad . \quad . \quad . \quad . \quad (1)$$

where

p = absolute pressure
V_n = volume occupied by n moles
z = compressibility factor
n = number of moles of gas
M = molecular weight of gas
m = mass of n moles of gas = nM
R = universal gas constant
T = absolute temperature

As all gases approach ideality as the pressure approaches zero, z approaches unity as p approaches zero.

The density ρ of a gas on a mass-basis, rather than a mole-basis, is expressed as

$$\rho = \frac{m}{V_n} \quad . \quad . \quad (2)$$

where ρ = density (lb cu ft, g./liter, etc.) By application of Equation (1), Equation (2) may be written as

$$\rho = \frac{pM}{zRT} \quad . \quad . \quad (3)$$

If the subscript "x" indicates the experimental gas, and the subscript "s" indicates the standard gas, the condition of equal density imposed by the gas density balance may be represented by the equations

$$\rho_x = \rho_s \quad . \quad . \quad . \quad . \quad (4)$$

$$\frac{p_x M_x}{z_x R T_x} = \frac{p_s M_s}{z_s R T_s} \quad . \quad . \quad (5)$$

The constant R may be eliminated from Equation (5), and the equation may be arranged in the following form:

$$\frac{p_x}{p_s}\frac{M_x}{M_s} = \frac{z_x}{z_s}\frac{T_x}{T_s} \quad . \quad . \quad (6)$$

From Equation (6) may be deduced the three methods for the use of the gas density balance.

Gas Density Balance Methods

The Method of Specific Gravities. Often, particularly in field work, it is desired to know only the specific gravity of the experimental gas. Specific gravity is defined as the ratio of the density of the experimental gas to the density of air, both gases being at the same temperature and pressure. Usually the pressure is one atmosphere, although specific gravities may be reported at any pressure as well as at any temperature. The development here will be kept general in this respect. If p'_x is the density of the experimental gas and p'_s is the density of air, both at a pressure p′ and a temperature t′ (absolute temperature T′), the definition of specific gravity combined with Equation (3) indicates that

$$\text{Sp. Gr.} = \frac{p'_x}{p'_s} = \frac{p'M_x/z'_x RT'}{p'M_s/z'_s RT'}$$

or,

$$\text{Sp. Gr.} = \frac{M_x}{M_s}\frac{z'_s}{z'_x}$$

where
Sp. Gr. = specific gravity of experimental gas at p′ and t′

M = molecular weight
z′ = compressibility factor at p′ and t′ subscript "x" indicates experimental gas subscript "s" indicates air

Equation (6), which relates the balancing pressures and temperatures observed in the gas density balance, may be rewritten as

$$\frac{M_x}{M_s} = \frac{p_s}{p_x}\frac{T_x}{T_s}\frac{z_x}{z_s} \quad . \quad . \quad (6a)$$

A combination of Equations (6a) and (7) shows that the specific gravity at p′ and t′ may be expressed in terms of the balancing pressures and temperatures, the compressibility factors at these temperatures and pressures, and the compressibility factors at p′ and t′.

$$\text{Sp. Gr.} = \frac{p_s}{p_x}\frac{T_x}{T_s}\frac{z's}{z_s}\frac{z_x}{z'_x} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

As a rule, the operator of a gas density balance is not so fortunate as to know the compressibility behavior of the gas of which he is determining the specific gravity. Consequently, he is unable to evaluate the factor z_x/z'_x in Equation (8). For the more compressible gases, the assumption that this factor is unity can introduce error considerably larger than the experimental error of the balance. The only solution to the dilemma lies in making $p' = p_x$ and $T' = T_x$; that is, the specific gravity determined by the gas density balance must be considered as the specific gravity of the gas at the balancing pressure p_x and the balancing temperature t_x of the gas. If it is desired to report the specific gravity at a pressure of one atmosphere, the balance must be adjusted until the balancing pressure of the experimental gas in one atmosphere. Under these conditions, the specific gravity of the gas at p_x and t_x is given by the equation

$$\text{Sp. Gr.} = \frac{p_s}{p_x}\frac{T_x}{T_s}\frac{z's}{z_s} \quad . \quad (8a)$$

where
z'_s = compressibility factor of air at p_x and t_x

z_s = compressibility factor of air at p_s and t_s

The necessary information is available to calculate z'_s/z_s in Equation (8a). As most gas density balances are limited to pressures, however, no higher than two atmospheres, and because air is so very nearly ideal, the assumption that this ratio is unity will generally introduce an error no greater than 0.05 per cent. *Subject to this error*, then, Equation (8a) may be written as

$$\text{Sp. Gr. (at } p_x \text{ and } t_x) = \frac{p_s}{p_x}\frac{T_x}{T_s} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8b)$$

This is the equation generally used to calculate specific gravities from gas density balance determinations.

The Method of Limiting Pressures. The principle and technique of the method of limiting pressures was explained in some detail by Cawood and Patterson,[7] who employed it in the determination of the atomic weights of several elements. Apparently the greatest use of this method has been in the field of molecular and atomic weight determinations, although it does have distinct possibilities in the field of low-pressure gas compressibilities as well. The method is based upon the experimentally observed fact that the compressibility factor isotherms of a large number of gases become linear with respect to pressure at low pressures. Cawood and Patterson[6] found that the pV-vs.-p isotherms, and hence the z-vs.-p isotherms, of ethylene, carbon dioxide, nitrous oxide, and sulfur dioxide were linear within the limits of their experimental accuracy up to a pressure of 3 meters of Hg. Bottomley, Massie, and Whytlaw-Gray[3] investigated the linearity below atmospheric pressure of the pV vs. p isotherms of carbon monoxide, carbon dioxide, nitrous oxide, oxygen, ethylene, and propane and found that the deviation from linearity of the individual data points did not exceed 0.002 per cent for any of these gases. Presumably, then, the compressibility factor isotherms of all gases approach a linear function of pressure as the pressure approaches zero, and, at pressures below two atmospheres, many deviate only very slightly from linear behavior.

This linearity may be represented by the equation

$$z = 1 - Ap \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

in which A is a function of temperature only. If Equation (9) applies to both the experimental gas and the standard gas in a gas density balance investigation, and, using the nomenclature of Equation (6), if the ratio p_x/p_s be called r, Equation (9) may be written for both gases as

$$z_x = 1 - A_x p_x \quad . \quad . \quad . \quad . \quad . \quad (9a)$$

$$z_s = 1 - A_s p_s = 1 - A_s p_x/r \quad . \quad (9b)$$

If Equation (6) is arranged so that it is explicit in p_x/p_s and then combined with Equations (9a) and (9b), there results the following equation:

$$\frac{p_x}{p_s} = r = \frac{M_s}{M_x}\frac{T_x}{T_s}\frac{1 - A_x p_x}{1 - A_s p_x / r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Although it is not essential to this method that the experimental-gas and standard-gas balancing temperatures be the same, it is necessary that the temperature of each gas be constant for the several determinations required to establish an isotherm; consequently, the usual and most desirable procedure is to hold T_x equal to T_s and at a constant value throughout the series of determinations. The solution of Equation (10) for r then results in the following equation:

$$r = \left[A_s - A_x \frac{M_s}{M_x}\right] p_x + \frac{M_s}{M_x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

For two gases at a constant temperature, A_s, A_x, M_s, and M_x are all constant. Consequently, if Equation (9) applies to both gases, the r-vs-p_x isotherm is linear, with a slope of $(A_s - A_x M_s/M_x)$ and an intercept of M_s/M_x at $p_x = 0$. This characteristic is illustrated in Fig. 2.

The versatility of Equation (11) and the linear plot that it represents is remarkable. If the molecular weight of the standard gas M_s is known, the molecular weight of the experimental gas M_x may be calculated from the intercept; no knowledge at all is required of the values of A_s and A_x to accomplish this. On the other hand, should the unlikely situation exist in which A_s is known but not M_s, A_x may be calculated from the slope, the intercept, and the known value of A_s, but M_x may not be calculated. If A_s and M_s are both known, A_x and M_x may both be calculated. As this situation represents the maximum amount of derived information, it is customary to select as a standard gas one for which M_s and A_s (at the desired temperatures) are known. When more than one isotherm is determined, extrapolation to zero pressure is made more accurate, as all isotherms for a given pair of gases must extrapolate to the same point. Finally, when both M_s and M_x are known, as is often the case in low-pressure compressibility work, the point of extrapolation is known, thereby requiring fewer data points to establish the isotherm.

Although linearity of the compressibility factor isotherms of both gases is the basis of Equation (11), this fact should not be construed as meaning that it is necessary to know beforehand the maximum pressures at which linearity is observed for the two gases. The r-vs.-p_x isotherm may exhibit curvature at the higher pressures, but it will become linear as the pressure decreases, and it is this linear portion to which Equation (11) applies. Examination of Equation (11) indicates, however, that the r-vs.-p_x isotherm might remain more nearly linear at higher pressures than the z-vs.-p isotherms for either the experimental gas or the standard gas; consequently, caution must be exercised in calculating values of z_x from A_x in Equation (9a) at higher pressures.

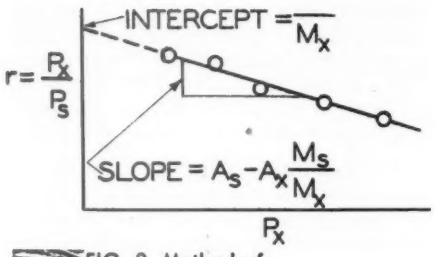

FIG. 2. Method of limiting pressures.

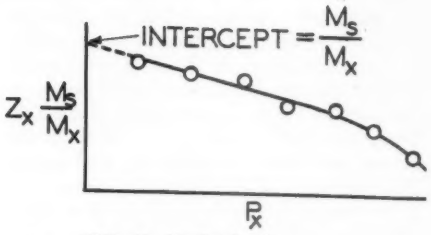

FIG. 3. Method of compressibility factors.

Method of Compressibility Factors.

The method of compressibility factors is similar to the method of limiting pressures in the experimental approach to the problem. It differs from the latter method, however, in that the compressibility isotherm of the standard gas must be known for the experimental temperature, but it has the compensating advantage that no assumption of linearity is involved. The compressibility isotherms of both the experimental and standard gases may possess any degree of curvature over the experimental pressure range.

Equation (6) may be written in the following two forms:

$$z_x \frac{M_s}{M_x} = z_s \frac{p_x}{p_s}\frac{T_s}{T_x} \quad . \quad . \quad (6b)$$

$$z_x = z_s \frac{M_x}{M_s}\frac{p_x}{p_s}\frac{T_s}{T_x} \quad . \quad . \quad (6c)$$

A plot of hypothetical experimental data according to Equation (6b) is shown in Fig. 3. Since $z_x = 1$ at $p_x = 0$, the intercept of the isotherm is the molecular weight ratio M_s/M_x. Consequently, it is not necessary to know either M_s or M_x to determine the compressibility factor isotherm of the experimental gas. If the experimental data are plotted as in Fig. 3 and the ratio M_s/M_x determined by extrapolation, z_x may then be calculated for each experimental point by means of Equation (6c). In addition, if M_s is known, which is the usual case, M_x may be determined. If M_s and M_x are both known, the data may be plotted according to Equation (6c), with compressibility factors of the experimental gas being calculated directly for each experimental point. The only requirement for linearity of either type of plot is that z_x vary linearly with p_x, *i.e.*, that the experimental gas possess a linear compressibility factor isotherm over the experimental pressure range. Although it is not necessary that T_s and T_x be equal for any single point or even over the entire range of isothermal points, T_x must be held constant for the resulting curve to have significance as an isotherm. Finally, it should be noted that, for a given pair of experimental and standard gases, all isotherms plotted according to Equation (6b) must extrapolate to a common point at $p_x = 0$. Regardless of the experimental gas and the standard gas, data plotted according to Equation (6c) must extrapolate to $z_x = 1$ at $p_x = 0$.

Air As the Standard Gas

As the specific gravity of a gas is referred to air as unity, the method of specific gravities permits no standard gas other than air to be used. For the other two methods, however, any gas that remains in the gaseous state over the pressure range involved may be satisfactory as a standard gas. It is certainly desirable that both the molecular weight of the standard gas and its compressibility behavior be known. In addition, it is advantageous for the method of limiting pressures if the compressibility factor isotherm of the standard gas is linear over the experimental pressure range for that gas. As most gas density balances have a fairly low maximum pressure of safe operation, and since the balancing pressure ratio p_x/p_s varies approximately as the inverse of the molecular weight ratio M_x/M_s, the molecular weight of the standard gas should not be a great deal less than that of the experimental gas. In such a case, the standard-gas pressure would then be "controlling," and the maximum experimental-gas pressure would be considerably less than the maximum permissible balance pressure. On the other hand, neither should the molecular weight of the standard gas be a great deal more than that of the experimental gas, for then the minimum experimental-gas balancing pressure would be limited by the lowest standard-gas balancing pressure that could be measured with sufficient accuracy. Consequently, the most desirable standard gas would be that which had a molecular weight most nearly the same as that of the experimental gas. Ethylene has been used as the standard gas for investigations of the density of atmospheric air[17, 18], and oxygen has been used for investigations of propane[5, 14]. In addition, from the practical standpoint, the standard gas should be inexpensive and easily obtainable.

Atmospheric air, with the carbon dioxide and water vapor removed, meets all of these conditions quite well. Its average composition [12] and mean molecular weight[1] at the surface of the earth are well established. It is very nearly an ideal gas and, over a wide range of

temperatures and up to all pressures encountered in gas density balance work, it possesses linear compressibility factor isotherms. Its mean molecular weight of 28.964[1] is within the molecular weight range of the light hydrocarbons and many other gases. It is everywhere available, inexpensive, and easily compressed. Two characteristics of atmospheric air have, however, led some to believe that it is unsatisfactory as a standard gas. These two characteristics are the apparent variation in the mean molecular weight of atmospheric air and the lack of comprehensive low-pressure compressibility data for air. The following discussion of these two difficulties is intended to show that air is in reality very satisfactory as a standard gas for most gas density balance investigations.

Variations in the Molecular Weight of Air. For more than 75 years, it has been known that the density of atmospheric air at a fixed temperature and pressure is subject to variations. In effect, this behavior may be considered to represent an apparent variation in the mean molecular weight of the air, although this possible explanation has never been verified. Investigations in this field have dealt with both the variation at a given location and the variation with geographic location, particularly with altitude. Attempts have been made to explain the variations in terms of varying oxygen contents, to explain the cause of the variation with altitude (the nature of which is contrary to the expected variation with altitude), and to correlate variations at a given location with atmospheric conditions[2, 10, 13, 15, 18]. These attempts have been only partially successful, and the theories postulated have been supported rather poorly by the experimental data. In what is apparently the most recent investigation, and very probably the most accurate, Stock, Ramser, and Eyber[17] made 34 determinations of air densities at 19.9 C and one atmosphere. Their maximum observed variation was 0.09 per cent, which was considerably greater than their expected experimental error and, they concluded, too great to be explained in terms of variation of oxygen content. In addition, they were able to find no correlation between atmospheric conditions and these variations.

The questions apparently still remain unanswered, the only conclusion without question being that the composition and apparent mean molecular weight of atmospheric air do vary. Nevertheless, one fact does present itself clearly. The maximum deviations observed have been of the order of 0.10 per cent; the maximum deviations from the mean have been no more than 0.05 per cent. For any one sample of air, the probable deviations from the mean would most certainly be less than 0.05 per cent. Furthermore, since the most recent work indicates that such variations in air density are apparently random, for cases in which air is used as a standard gas and in which all of the data for an isotherm are not taken within a short period of time, this randomness should reduce the net error in the isotherm to no more than a few hundredths of a per cent, if that large. For most compressibility investigations with a gas density balance, such an error is negligible.

Compressibility Isotherms of Air. Although there is a relatively large amount of experimental data in the literature pertaining to the compressibility of air at low pressures, the data are nonetheless insufficient to permit the prediction of any desired compressibility isotherm with accuracy. To perform the interpolations between the available data, an equation of state for air is most useful. Such an equation of state must be well supported by the experimental data in the temperature and pressure range for which it is to be used. The Beattie-Bridgeman Equation of State meets these requirements.

The Beattie-Bridgeman equation may be written in a series or virial form, as shown in the following Equation (1):

$$pV = RT + \frac{\beta}{V} + \frac{\partial}{V^2} + \frac{\delta}{V^3} \quad . \quad (12)$$

The coefficients, β, ∂, and δ are the second, third, and fourth virial coefficients, respectively, and are functions of temperature only. For air at low pressures and moderate temperatures, Equation (12) may be simplified by the omission of the terms containing V^2 and V^3, as these terms contribute a negligible amount to the value of pV.

$$pV = RT + \frac{\beta}{V} \quad . \quad . \quad (12a)$$

The compressibility factor z is defined in terms of the molal specific volume V by the equation

$$pV = zRT \quad . \quad . \quad . \quad (1a)$$

If V is eliminated in Equation (12a) by means of Equation (1a), a quadratic in z results. Of the two solutions to the quadratic, one is ruled out by the requirement that $z = 1$ at $p = 0$; the remaining solution is

$$z = \frac{1}{2} + \sqrt{\frac{1}{4} + \frac{\beta p}{(RT)^2}} \quad (13)$$

Beattie and Bridgeman have defined β by the equation *(1)*

$$B = RTB_o - A_o - Rc/T^2 \quad . \quad (13a)$$

where

$A_o = 1.3012$
$B_o = 0.04611$
$c = 4.34 \times 10^4$
$R = 0.08206$
$0°C = 273.13°K$

Although Equation (13) is not linear with p, values of z calculated from it at pressures up to two atmospheres deviate to slightly from linearity as to permit a straight line to represent a compressibility isotherm with an error that is entirely negligible. A binomial expansion of Equation (13) will demonstrate that, for very small values of $\beta p/(RT)^2$, the equation is equivalent to Equation (9), with $A = -\beta/(RT)^2$.

Compressibility factors calculated from Equation (13) have been compared with those calculated from the data of Witkowski[19] and of Holborn and Otto[11], from the averages of the densities reported by Guye *et al*[10], by Stock *et al*[17], and by Moles[15], and from the average densities determined by Rayleigh, Leduc, Guye, von Jolly, and Schultze as reported by Moles[15]. These data covered a range of temperatures from 0 C to 100 C and a range of pressures from 1 atm to approximately 1.3 atm. The maximum deviation of the equation-of-state compressibility factors from the experimental compressibility factors was only 0.02 per cent; the average deviation was only 0.01 per cent. Consequently, the modified form of the Beattie-Bridgeman equation of state, represented by Equation (13), is of sufficient accuracy for most gas density balance investigations using atmospheric air as the standard gas.

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(Part 2 follows on next page)

PART 2 — COMPRESSIBILITY ISOTHERMS OF METHANE ETHANE, PROPANE, AND N-BUTANE AT LOW PRESSURES

I. H. SILBERBERG, P. K. KUO†, JOHN J. McKETTA, JR.

A SURVEY of the literature pertaining to the compressibility of light paraffin hydrocarbons has indicated that, although the field of high-pressure compressibilities has been adequately investigated, there is a general dearth of reliable and comprehensive information regarding the compressibilities of these hydrocarbons at low pressures. The obvious reason for the apparent neglect of the low-pressure regions is that, for many purposes, sufficient accuracy may be obtained by assuming ideal-gas behavior, by using the generalized low-pressure compressibility charts, or by extrapolating the available high-pressure data. When accurate compressibility information at low pressures is desired, however, in analytical work, for example, the uncertainties arising from the use of these approximate methods may be of considerable concern.

On the basis of the extremely accurate work that has been done with gas density balances in the past, the writers were of the opinion that such an instrument was ideally adapted for the comprehensive investigation of the compressibilities at low pressures of the light paraffin hydrocarbons. In order to attach a double significance to this work, it was decided to employ one of the commercial varieties of gas density balances, thereby permitting the results of this investigation also to serve as an indication of the value of such an instrument in precision work. The experimental hydrocarbons selected were methane, ethane, propane, and normal butane.

Experimental Apparatus

The Ac-Me No. 3511 gas density balance was selected for this investigation. This balance was tested by Smith *et al.*[39] and found to be highly satisfactory. The internal mechanism of this balance is shown in Fig. 1. The sealed aluminum alloy float (No. 40 in Fig. 1) is attached to the end of a brass beam. The suspension mechanism (No. 42) utilizes two crossed phosphor-bronze foil strips on each side of the beam. Two counterweights (No. 43) are threaded on the beam; movement of the counter-weights away from the suspension decreases the balancing density, and conversely. The sensitivity-adjusting weight (No. 41) is mounted directly over the suspension. Movement of this weight away from the suspension increases the sensitivity of the balance. The sensitivity of the balance was adjusted using air at room temperature so that the pressure change producing a perceptible change in the beam position was of the same order of magnitude as the smallest pressure change that could be detected with the pressure-measuring apparatus. Just above the locking-lever (No. 45) is a window through which the position of the calibrated scale on the end of the beam may be observed in relation to the wire stretched horizontally across the window. The balance was modified by the insertion of an iron-constantan thermocouple (No. 44) through two Neoprene-packed glands in the face of the balance.

WANT DATA

There are many researchers who have fragmentary low pressure compressibility data which have never been published. The writers of this paper would appreciate it if these researchers would send any such data to them. An estimation of the experimental error of such data would be most helpful. If sufficient data of this nature are submitted the writers will correlate the data and publish the results with full acknowledgment of the source of the data.

The mechanism of the Ac-Me No. 3511 balance is enclosed in a chrome-plated steel cylinder equipped with a spirit level and a levelling device. The face of the balance is attached to this case by means of six cap screws, a Neoprene annular gasket insuring a leak-tight junction. On the top of the balance case are four ¼-in. standard pipe thread outlets to which were connected, through needle valves, the hydrocarbon source, the air source, the vacuum line, and the mercury manometer. The balance was enclosed in the constant-temperature air bath, an insulated plywood box containing a windowed door to permit access to the balance and viewing the position of the beam.

At the lower temperatures, incandescent lamps were employed as heaters in the air bath. At the higher temperatures, conventional resistance heaters were used. The control-heater circuit was operated through a modified de Khotinsky bimetallic helix as the temperature-sensitive element and a mechanical-latch magnetic switch as the relay. The balance was shielded from the heaters by a baffle. Air was circulated through the bath by means of small centrifugal blowers. Temperature fluctuations at any given point in the bath were small, generally less than 0.2 F. The temperature gradient through the bath tended to increase with the bath temperature, but, because of the mixing effect of the oscillating float during readings, no appreciable temperature gradient was believed to have existed within the balance case.

Temperatures were measured by means of an iron-constantan thermocouple and a precision potentiometer. The thermocouple and potentiometer were calibrated as a unit against standard thermometers calibrated by the U. S. Bureau of Standards. These standard thermometers were accurate to 0.02 F. Cold-junction temperatures were determined with an accuracy of 0.02 F. The overall accuracy in the determination of the temperature within the balance was believed to be 0.05 F.

The pressure within the balance case was measured by means of a mercury U-tube manometer in conjunction with a mercury barometer. The manometer was constructed of 6 mm. glass tubing. The mercury was purified by several successive washings in dilute nitric acid, running tap water, and distilled water, and then was dried at 105 C for approximately one hour. Because the calculations of the experimental results involved pressure ratios and because the slopes of the compressibility isotherms are small, a deviation of the density of the manometric mercury from that of pure mercury would have introduced negligible error. The pressure difference indicated by the manometer was determined with a precision cathetometer calibrated to 0.05 mm. The difference in the meniscus heights of the two legs of the manometer rarely exceeded 0.15 mm; consequently, no corrections for capillary depression were made. Barometric pressure was determined from a mercury-in-glass barometer calibrated to 0.1 mm Hg. Total pressures in millimeters of mercury were corrected to 0°C and to the standard acceleration of gravity, 980.665 cm/sec/sec[35]. The total error in the pressure measurements was believed not to exceed 0.2 mm Hg.

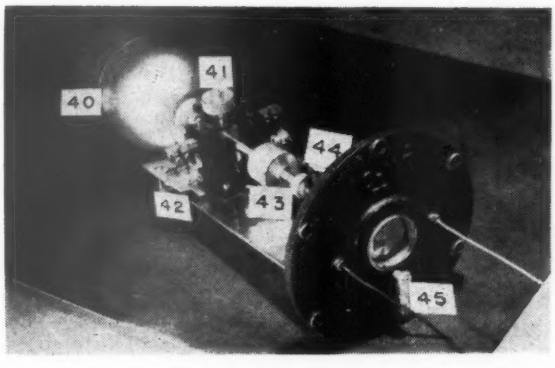

FIG. 1. Gas density balance mechanism.

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Materials

The experimental hydrocarbons were methane, ethane, propane, and normal butane. The ethane was of research grade, certified to have a purity greater than 99.99 per cent ethane. The methane, propane, and normal butane were pure-grade hydrocarbons. As it was desirable to know the composition and mean molecular weight of these hydrocarbons accurately, they were analyzed by mass-spectrographic means, the estimated error of the analysis being 0.1 per cent. The methane analyzed 98.72 per cent methane, the impurities consisting of ethane, propane, normal butane, isobutane, nitrogen, and carbon dioxide. The carbon dioxide contained in the methane was removed by passing the gas through tubes containing Ascarite and Dehydrite in the methane line leading to the balance. The mean molecular weight of the methane was calculated to be 16.225 on a carbon dioxide-free basis. The propane analyzed 99.80 per cent propane, the impurity being methane. The mean molecular weight of the propane was calculated to be 44.038. The normal butane analyzed 99.50 per cent normal butane, 0.40 per cent isobutane, and 0.10 per cent propane. The mean molecular weight of the normal butane was calculated to be 58.106.

Air from a 90 psig air line was used as the standard gas. Before entering the balance, the air was passed successively through tubes of calcium chloride, Ascarite, and Dehydrite to remove all of the water vapor and carbon dioxide.

Test of Balance Accuracy

In order to determine if the density balance and its auxiliary apparatus were free from errors other than random ones, compressibility factors of normal butane at 91.8 F and 745 mm Hg were determined by both the density balance and the method of direct weighing, often called the "balloon method." For this latter method, two Pyrex bulbs of approximately 500 cc capacity were employed. Eight determinations with the direct weighing method produced a mean compressibility factor of 0.9740, with a standard deviation (root mean square error) of 0.00051 and a probable error of the mean of 0.00011. Seven determinations with the gas density balance resulted in a mean compressibility factor of 0.9738, with a standard deviation of 0.00056 and a probable error of the mean of 0.00009. On the basis of this good agreement, it was concluded that the gas density balance was free of non-random errors. Furthermore, as adsorption would have affected the results of the two methods in opposite directions, it was also concluded that adsorption on the balance float would cause negligible error in this investigation.

Experimental Procedure

The most generally useful manner in which compressibility data can be presented is in the form of the compressibility factor z, which is defined as

$$z = \frac{pV}{RT} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where

z = compressibility factor
p = absolute pressure
V = molal volume
R = gas constant
T = absolute temperature

The method of compressibility factors, discussed in the preceding paper, is that method for the gas density balance that can give compressibility factors directly and that makes no assumption regarding the shape of the compressibility isotherm. The equations that apply to this method are

$$z_x \frac{M_s}{M_x} = z_s \frac{p_x T_s}{p_s T_x} \quad . \quad . \quad (2)$$

$$z_x = z_s \frac{M_x p_x T_s}{M_s p_s T_x} \quad . \quad . \quad (3)$$

where

p = balancing pressure (absolute)
T = balancing temperature on absolute scale
M = molecular weight
subscript "x" indicates experimental gas
subscript "s" indicates standard gas

Equation (2) is particularly useful when the molecular weight of either or both the experimental gas and standard gas in unknown. Equation (3) may be used when the molecular weights of both gases are known.

In this investigation, a complete run consisted of two determinations of the balancing pressure and temperature of air and one determination of the balancing pressure and temperature of each of several hydrocarbons. Each run was begun and ended with an air determination. The first run of each isothermal sets of runs was made with a balancing density corresponding to an air pressure of approximately two atmospheres, the maximum safe operating pressure of the Ac-Me No. 3511 balance. As methane has an appreciably lower molecular weight than air, methane would have required a balancing pressure greater than two atmospheres and consequently could not be included in this run. The first run then consisted of determinations on air, ethane, propane, normal butane, and air, in that order. The counter-weights were then set so that a lower balancing density was required, and the procedure was repeated. When a counter-weight setting that required a methane pressure no greater than two atmospheres was reached, methane was included in the runs. Eventually, the required balancing density was reduced to the point that the balancing pressure of normal butane was too low to be determined with sufficient accuracy. Normal butane was then dropped out of the runs for that isotherm. Similarly, at a somewhat lower balancing density, propane had to be omitted.

Before it was charged with each gas, the balance was thoroughly purged. The balance was first evacuated to a pressure below 5 mm Hg and then filled to approximately atmospheric pressure with the gas to be charged. This purging was repeated at least three times for each gas, reducing any contamination to an entirely negligible amount.

The balancing pressure of a gas was determined as that pressure that caused successive oscillations about zero to be of very slightly decreasing amplitude. Balancing temperatures were determined both before and after the pressure determinations and were never observed to have changed significantly. Balancing temperatures rarely differed by more than 0.3 F from the nominal temperature of the isotherm.

The Beattie-Bridgeman equation of state for air[3] was used to calculate the values of z_s needed in Equations (2) and (3). The value of the molecular weight of dry, CO_2-free air used was $M_s = 28.964$[3]. The compressibility factors of ethane, propane, and normal butane were calculated directly from Equation (3), using the mean molecular weights calculated from the mass-spectrographic analyses. As methane has a relatively low molecular weight, the possible error in the mean molecular weight of that gas introduced by the uncertainty of 0.1 per cent in the analysis indicated that Equation (2) should be used for methane. The ratio M_s/M_x was obtained by extrapolating the experimental data to zero pressure, according to Equation (2), and the values for z_x for methane were then calculated from Equation (3). For all four hydrocarbons, compressibility factors were calculated on the basis of both the initial and final air determination in each run, the average of the two values then being taken as the experimental value.

Experimental Results

The compressibility isotherms of ethane, propane, and normal butane were determined at seven temperatures between 90 F and 200 F. Because of poor reproducibility, the compressibility isotherms of methane were investigated at only two temperatures, 90 F and 110 F. In general, reproducibility tended to decrease as the temperature was increased, so it was felt that no improvement over the existing data on methane in the literature could be made. The poor reproducibility with methane was partially explained by an investigation of the "human error" in determining the balance point in relation to the density. It was found that this error tended to increase rather sharply as the density was decreased. No explanation was found for the decrease in reproducibility as the temperature was increased.

A sample of the experimental data, that taken at 90 F, is shown in Fig. 2. All isotherms were drawn as straight lines through the experimental points. The fact that straight lines drawn from $z = 1$ at $p = 0$ fit the experimental data on propane and normal butane indicates that the mean molecular weights calculated for those gases from their analyses were correct within the limits of ex-

perimental accuracy. On the other hand, the excellent fit of such a straight line to the ethane data served to confirm the mean molecular weight of air employed and to demonstrate that significant variations in this molecular weight did not occur. The methane data indicated that the mean molecular weight of that gas, calculated as 16.225 from the analysis, was too low. The mean molecular weight of methane determined from plotting the experimental data according to Equation (2) was 16.262, and this value was used to calculate the compressibility factors of methane at 90 F and 110 F. The reproducibility of the methane data was poor, however, and the uncertainty in this value 16.262 is estimated to be of the order of 0.1 per cent.

The assumption of linearity of the compressibility isotherms of these light paraffin hydrocarbons is not without justification. The experimental data in this investigation indicated that such linearity is probable, at least within the limits of the experimental accuracy. Actually, as Bottomley *et al*[9] have pointed out, theory predicts a slight curvature of the "z vs. p" isotherms toward the pressure axis at low pressures and below the critical temperature, that is, a negative curvature or negative value of $(\delta^2 z/\delta p^2)_T$. When curvature has been observed below the critical temperature, it has generally been negative. This negative curvature appears to be most probable, also, in view of the shape of these isotherms at higher pressures. The shape of the high-pressure isotherms indicate furthermore that this negative curvature might be expected to persist at low pressures at temperatures considerably above the critical temperature. Certainly, at some temperature between the critical temperature and the Boyle temperature, the temperature at which $(\delta z/\delta p)_T = 0$, at $p = 0$, the compressibility isotherms may be expected to begin exhibiting positive curvature at low pressures, that is, positive values of $(\delta^2 z/\delta p^2)_T$. The exact nature of this transition from negative to positive curvature has not been investigated experimentally, although it may be predicted by various equations of state.

Despite the theoretical predictions, the experimental observations on a large number of gases have shown that deviations from linearity of the compressibility isotherms at low pressures are extremely small. The maximum pressure to which linearity is observed appears to be larger in general for the more ideal gases. Also, it appears that the curvature of negatively-curved isotherms decreases as the temperature of the isotherm is increased; this behavior was observed by Cawood and Patterson[11] with dimethyl ether at 0 C and 21 C. The compressibility isotherms of many gases have been found not to deviate significantly from linearity up to pressures as high as three atmospheres.

Lambert and Phillips[23] detected no curvature below atmospheric pressure in the compressibility isotherm of methane at 68 F. Lambert *et al*[24] investigated the compressibility of ethane up to a pressure of one atmosphere and at temperatures from 68 to 176 F and found the isotherms to be linear. Casado *et al*[10] found no indication of curvature for propane at 69.4 F between pressures of 350 mm Hg and 700 mm Hg. Bottomley *et al*[9] investigated the compressibility of propane at 71.7 F between pressures of 185 mm Hg and 803 mm Hg and found that the deviation of individual data points from a linear isotherm did not exceed 0.004 per cent. The data of Beckers[8] on normal butane at 32 F show negative curvature but deviate only 0.01 per cent from a linear compressibility isotherm. Even for normal hexane at temperatures between 86 F and 230 F, Lambert *et al*[24] found the "pV vs. p" isotherms were linear up to pressure of one atmosphere.

In view of this overwhelming evidence favoring linearity of low-pressure compressibility isotherms, it was felt that there exists ample justification for the strictly linear representation employed for the results of this investigation. As this linearity of z with respect to pressure, expressed algebraically by the equation

$$z = 1 - Ap \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which A is a function of temperature only, permits the establishment of a compressibility factor isotherm with only one value of z, the experimental data of this investigation are presented in the form of compressibility factors at one atmosphere, determined from seven charts of the type of Fig. 2. These data are presented in Figs. 3, 4, 5, and 6. It should be noted that the ordinate in these figures, z at one atmosphere, may also be regarded as $1 - A$, where A has the dimensions of atm.$^{-1}$.

Data Comparison and Correlation

A comprehensive survey of the literature was made for compressibility data on methane, ethane, propane, and normal butane at low pressures. Special attention was paid to data obtained from

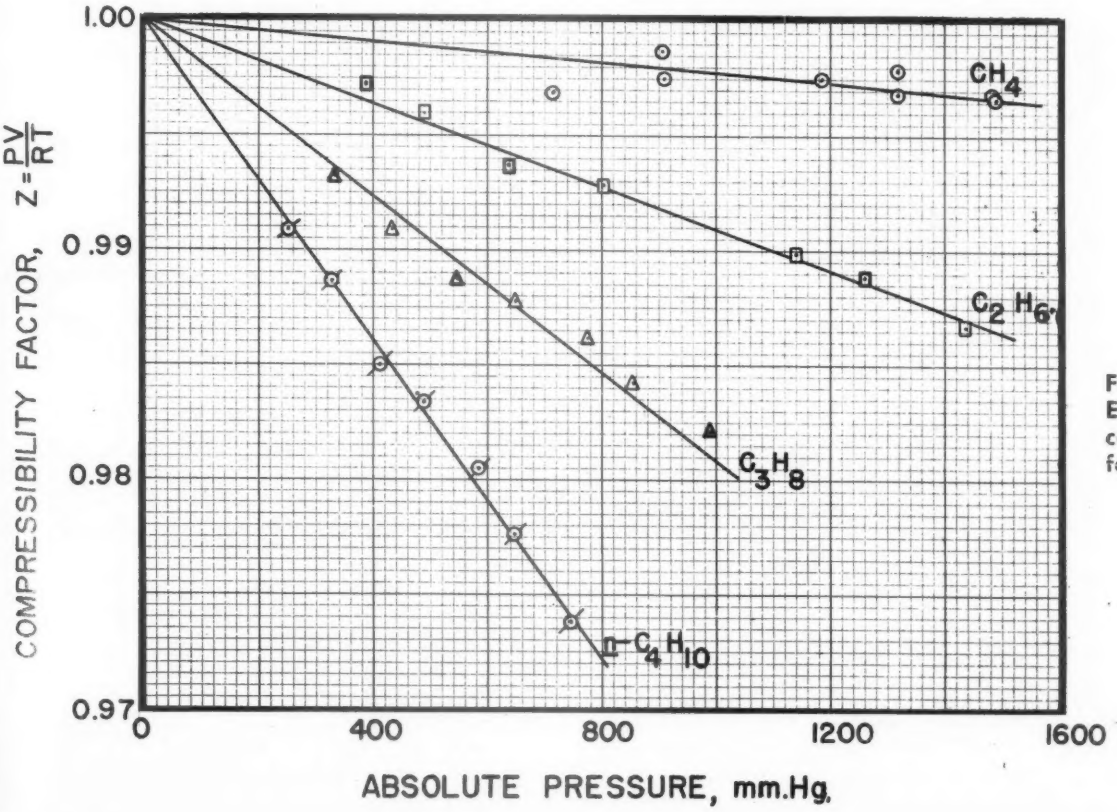

FIG. 2. Experimental compressibility factors at 90 F.

Materials

The experimental hydrocarbons were methane, ethane, propane, and normal butane. The ethane was of research grade, certified to have a purity greater than 99.99 per cent ethane. The methane, propane, and normal butane were pure-grade hydrocarbons. As it was desirable to know the composition and mean molecular weight of these hydrocarbons accurately, they were analyzed by mass-spectrographic means, the estimated error of the analysis being 0.1 per cent. The methane analyzed 98.72 per cent methane, the impurities consisting of ethane, propane, normal butane, isobutane, nitrogen, and carbon dioxide. The carbon dioxide contained in the methane was removed by passing the gas through tubes containing Ascarite and Dehydrite in the methane line leading to the balance. The mean molecular weight of the methane was calculated to be 16.225 on a carbon dioxide-free basis. The propane analyzed 99.80 per cent propane, the impurity being methane. The mean molecular weight of the propane was calculated to be 44.038. The normal butane analyzed 99.50 per cent normal butane, 0.40 per cent isobutane, and 0.10 per cent propane. The mean molecular weight of the normal butane was calculated to be 58.106.

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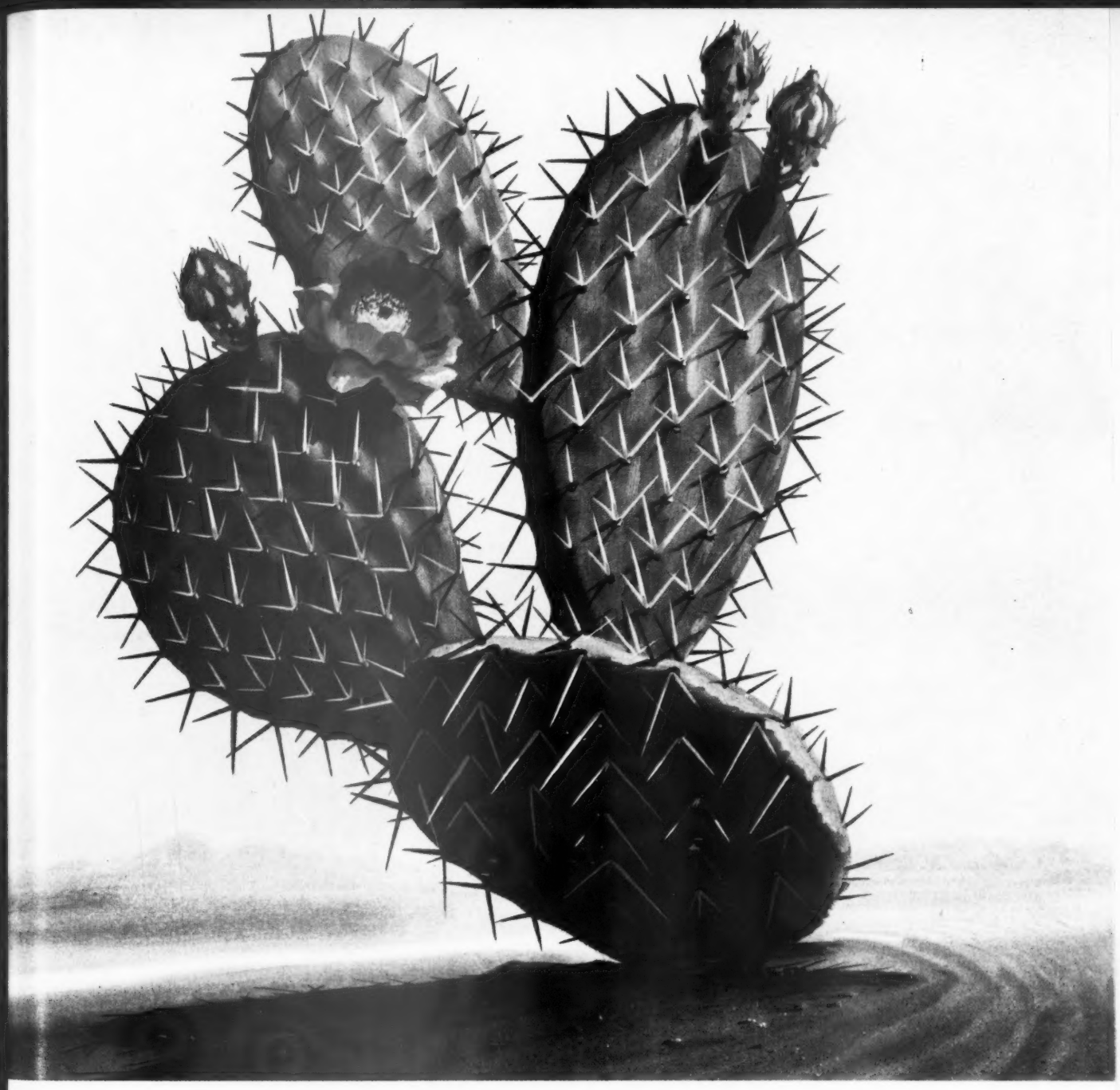

What is the most important point about our new Texas plant?

It probably would be more usual to announce the opening of Ethyl's new Texas plant by showing a large air view of the entire layout. However, this close-up of another kind of Texas plant better illustrates our point.

You see, the plant in the picture above is completely self-sustaining. Just give it sunlight, air, a little water, and a place to grow. It depends only upon raw materials to make the complex chemicals it needs to stay in business. In other words, it is a *completely integrated* plant . . . just like the new Ethyl plant at Houston, Texas.

Give Ethyl's new Texas plant the raw materials—such as pig lead, salt, petroleum gases, electricity—and it can make all the chemical ingredients needed in "Ethyl" antiknock compound. In this way the new plant is like Ethyl's plant

(*continued on next page*)

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

What is the most important point about our new Texas plant?

(*continued from preceding page*)

at Baton Rouge. Each is completely integrated—and is independent of the other.

We think this integration is an extremely important point to refiners. Today refiners are faced with the challenge of supplying great quantities of high-quality gasoline to meet the ever-increasing demands of American transportation. To perform this service, they need an uninterrupted supply of antiknock compound —which an *integrated* plant is best able to give them.

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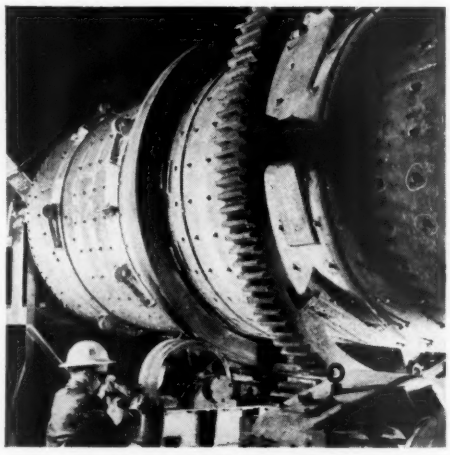

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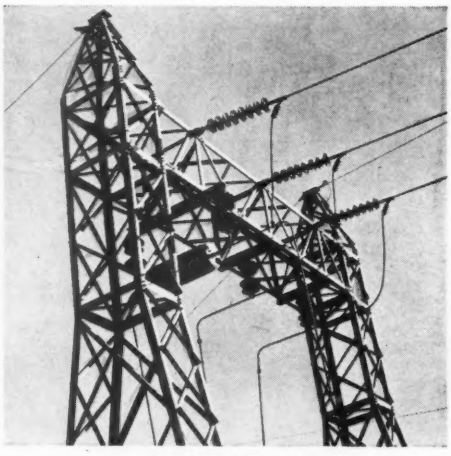
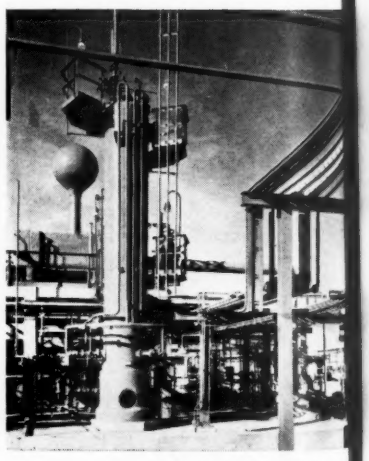


HIGH-VOLTAGE LINE FOR SODIUM CELLS



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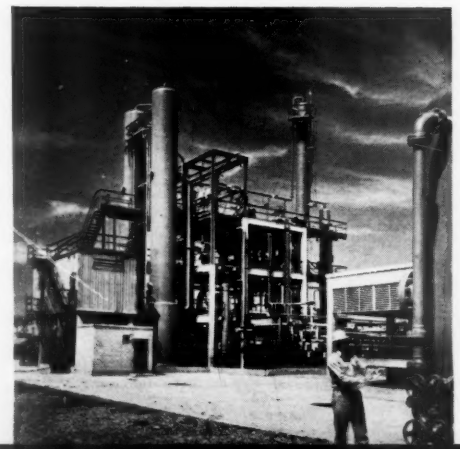
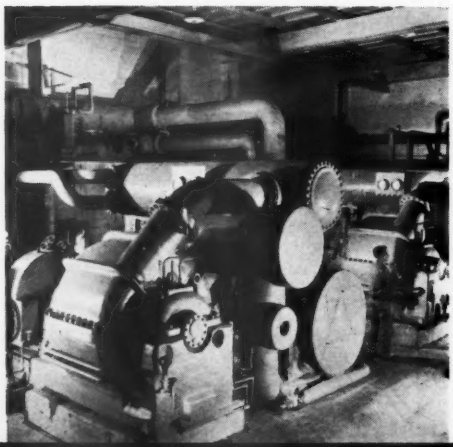


REFRIGERATION COMPRESSORS IN THE ETHYL CHLORIDE UNIT



TETRAETHYLLEAD MANUFACTURING BUILDING

perimental accuracy. On the other hand, the excellent fit of such a straight line to the ethane data served to confirm the mean molecular weight of air employed and to demonstrate that significant variations in this molecular weight did not occur. The methane data indicated that the mean molecular weight of that gas, calculated as 16.225 from the analysis, was too low. The mean molecular weight of methane determined from plotting the experimental data according to Equation (2) was 16.262, and this value was used to calculate the compressibility factors of methane at 90 F and 110 F. The reproducibility of the methane data was poor, however, and the uncertainty in this value 16.262 is estimated to be of the order of 0.1 per cent.

The assumption of linearity of the compressibility isotherms of these light paraffin hydrocarbons is not without justification. The experimental data in this investigation indicated that such linearity is probable, at least within the limits of the experimental accuracy. Actually, as Bottomley *et al*[9] have pointed out, theory predicts a slight curvature of the "z vs. p" isotherms toward the pressure axis at low pressures and below the critical temperature, that is, a negative curvature or negative value of $(\delta^2 z/\delta p^2)_T$. When curvature has been observed below the critical temperature, it has generally been negative. This negative curvature appears to be most probable, also, in view of the shape of these isotherms at higher pressures. The shape of the high-pressure isotherms indicate furthermore that this negative curvature might be expected to persist at low pressures at temperatures considerably above the critical temperature. Certainly, at some temperature between the critical temperature and the Boyle temperature, the temperature at which $(\delta z/\delta p)_T = 0$, at $p = 0$, the compressibility isotherms may be expected to begin exhibiting positive curvature at low pressures, that is, positive values of $(\delta^2 z/\delta p^2)_T$. The exact nature of this transition from negative to positive curvature has not been investigated experimentally, although it may be predicted by various equations of state.

Despite the theoretical predictions, the experimental observations on a large number of gases have shown that deviations from linearity of the compressibility isotherms at low pressures are extremely small. The maximum pressure to which linearity is observed appears to be larger in general for the more ideal gases. Also, it appears that the curvature of negatively-curved isotherms decreases as the temperature of the isotherm is increased; this behavior was observed by Cawood and Patterson[11] with dimethyl ether at 0 C and 21 C. The compressibility isotherms of many gases have been found not to deviate significantly from linearity up to pressures as high as three atmospheres.

Lambert and Phillips[23] detected no curvature below atmospheric pressure in the compressibility isotherm of methane at 68 F. Lambert *et al*[24] investigated the compressibility of ethane up to a pressure of one atmosphere and at temperatures from 68 to 176 F and found the isotherms to be linear. Casado *et al*[10] found no indication of curvature for propane at 69.4 F between pressures of 350 mm Hg and 700 mm Hg. Bottomley *et al*[9] investigated the compressibility of propane at 71.7 F between pressures of 185 mm Hg and 803 mm Hg and found that the deviation of individual data points from a linear isotherm did not exceed 0.004 per cent. The data of Beckers[8] on normal butane at 32 F show negative curvature but deviate only 0.01 per cent from a linear compressibility isotherm. Even for normal hexane at temperatures between 86 F and 230 F, Lambert *et al*[24] found the "pV vs. p" isotherms were linear up to pressure of one atmosphere.

In view of this overwhelming evidence favoring linearity of low-pressure compressibility isotherms, it was felt that there exists ample justification for the strictly linear representation employed for the results of this investigation. As this linearity of z with respect to pressure, expressed algebraically by the equation

$$z = 1 - Ap \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which A is a function of temperature only, permits the establishment of a compressibility factor isotherm with only one value of z, the experimental data of this investigation are presented in the form of compressibility factors at one atmosphere, determined from seven charts of the type of Fig. 2. These data are presented in Figs. 3, 4, 5, and 6. It should be noted that the ordinate in these figures, z at one atmosphere, may also be regarded as $1 - A$, where A has the dimensions of atm.$^{-1}$.

Data Comparison and Correlation

A comprehensive survey of the literature was made for compressibility data on methane, ethane, propane, and normal butane at low pressures. Special attention was paid to data obtained from

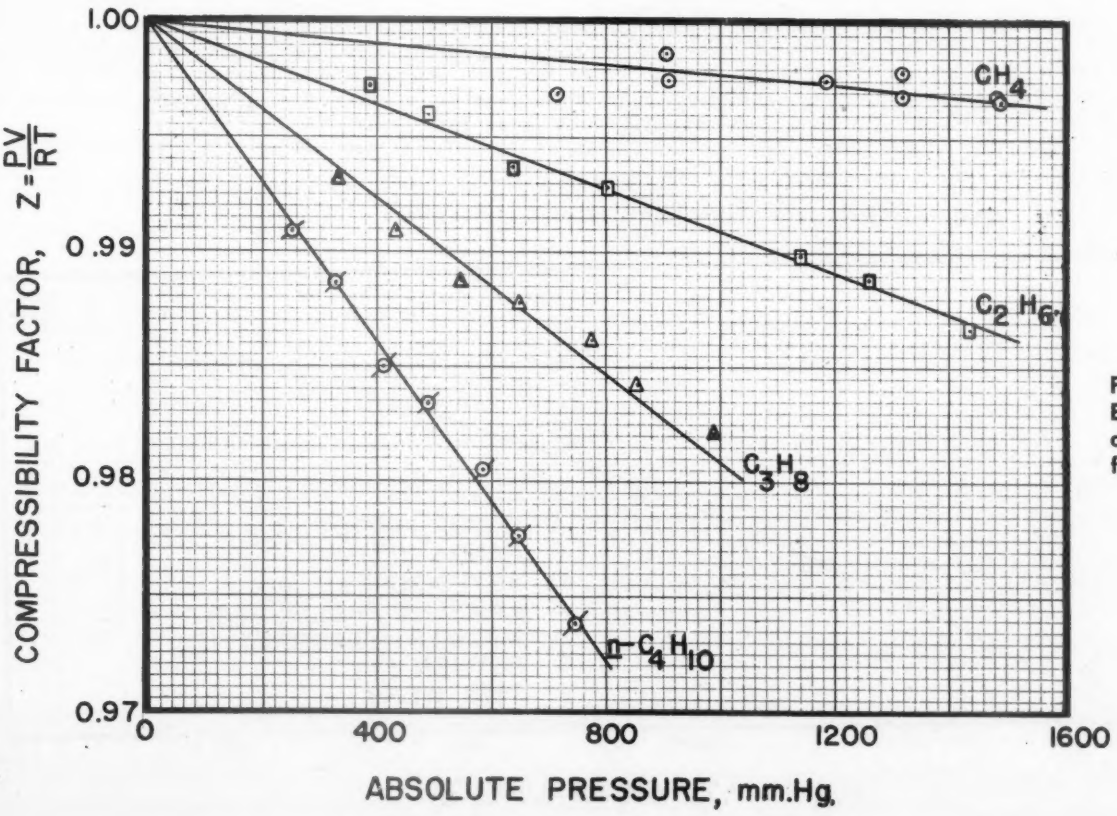


FIG. 2. Experimental compressibility factors at 90 F.

low-pressure investigations, as such data offered an opportunity both to confirm the results of this work and to extend its temperature range. When low-pressure data were tabulated by investigators along with the results of their high-pressure work, these data were also included for the purpose of comparison, although in general such data were determined by these authors from extrapolations to zero pressure. Naturally, such extrapolated data cannot be given the same importance as data taken at low pressures with apparatus designed for low-pressure work.

When the data were presented as densities or specific volumes, they were converted to molal volumes and compressibility factors were calculated according to Equation (1). Other data were presented as compressibility coefficients A in Equation (4) or as "second virial coefficients" in either the Berlin or Leiden type of series representation of pV. The method of calculation of compressibility factors from such data followed directly from the relations to which the reported values applied. Data presented in the form of Amagat units or as values of $1 + \lambda$ were converted to compressibility factors in the manner indicated by Kobe[21].

In all of these data conversions, such values of molecular weights and other constants were employed as would reproduce that quantity experimentally observed by the investigator. When the experimentally observed quantity was reported directly, the values employed in the data conversion were those presented in Table 1. These same constants and pure hydrocarbon molecular weights were employed everywhere else in this work, with the exception of the Beattie-Bridgeman equation of state for air, for which the value of R and $T_{0°C}$ used by the developers of that equation were employed. Equivalents of the gas constant R in other units were calculated from the value in Table 1, using the standard equivalents of length, mass, and temperature[35]

TABLE 1. Constants and molecular weights.[35]

Mol. Wt. Methane	= 16.042
Mol. Wt. Ethane	= 30.068
Mol. Wt. Propane	= 44.094
Mol. Wt. *n*-Butane	= 58.120

$$R = 0.0820544 \frac{\text{(liter) (atm.)}}{\text{(g.mole) (°K)}}$$

$$T_{0°C} = 273.16°K$$

1 Atm. = 14.696 psia = 760.00 mm Hg

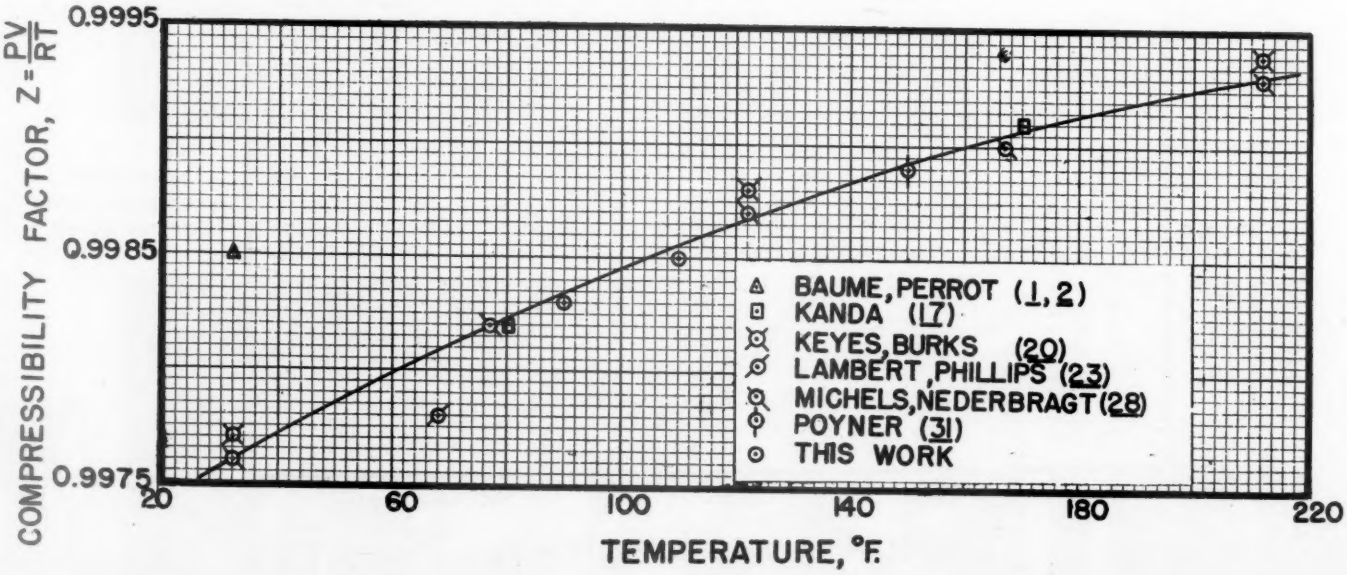
Methane (Fig. 3). The agreement of the existing data on methane is excellent, with one exception. The determination of the normal density by Baume and Perrot[1,2] leads to a compressibility factor that exhibits the greatest deviation from the remainder of the data. In 12 determinations, however, a maximum deviation of 0.18 per cent occurred, so the average reported by Baume and Perrot is not too reliable. It is interesting to note that earlier calculations from Baume and Perrot's value of 0.7168 grams/liter led to a value of 1.0024 for $1 + \lambda$, or a "z" at one atmosphere of 0.9976. Using more modern values of molecular weights, a "z" of 0.9985 is calculated. The compressibility coefficient determined by Lambert and Phillips[23], the compressibility factor determined by Poyner[31], and the second virial coefficients of Kanda[17] are all in good agreement with the values calculated from the virial-type equations of state fitted by Keyes and Burks[20] and by Michels and Nederbragt[28] to their high-pressure data. The extrapolated values reported by Kvalnes and Gaddy[22] in their high-pressure investigation agreed at all temperatures within better than 0.01 per cent with either the data of Keyes and Burks or the data of Michels and Nederbragt. Although these last three investigations were high-pressure in nature, the excellent inter-agreement at low pressures can hardly be ignored. Olds *et al*[29] did not tabulate their data at pressures below 200 psia, so no comparison with their results is possible. The compressibility factors at 90 F and 110 F from the present work agree well with the other data, but the uncertainty of the values is fairly high.

Ethane (Fig. 4). Lambert *et al*[24] investigated the second virial coefficients of ethane at pressures up to atmospheric and at temperatures ranging from 68 F to 176 F. The corresponding points in Fig. 4 were obtained by passing a smoothed curve through their experimental points. According to their statement regarding the accuracy of their work, the expected error in the compressibility factor at one atmosphere is 0.080 per cent at the lowest temperature, falling slightly to 0.068 per cent at the highest temperature. The deviation of their data from the results of the present investigation are within the limits of their expected errors except at temperatures above 160 F.

Baume and Perrot[2] and Stahrfoss[40] determined the normal density of ethane. Eucken and Parts[14] presented a value of the second virial coefficient at 32 F, determined in a low-pressure investigation at temperatures up to 32 F. Leduc[25] reported the specific gravity of ethane at 32 F and one atmosphere to be 1.0494; using 1.2929 grams/liter as the normal density of air, a normal density for ethane of 1.3568 grams/liter results. The compressibility factor in Fig. 4 was calculated from this value of the normal density.

Compressibility factors were calculated from the tabulated low-pressure data of Sage *et al*[37] presented with the report of their investigations up to 3500 psia. No low-pressure points were reported by Reamer *et al*[33], Beattie, Hadlock, and Poffenberger[4], or Beattie, Su, and Simard[7].

FIG. 3. Compressibility factors of methane at one atmosphere.



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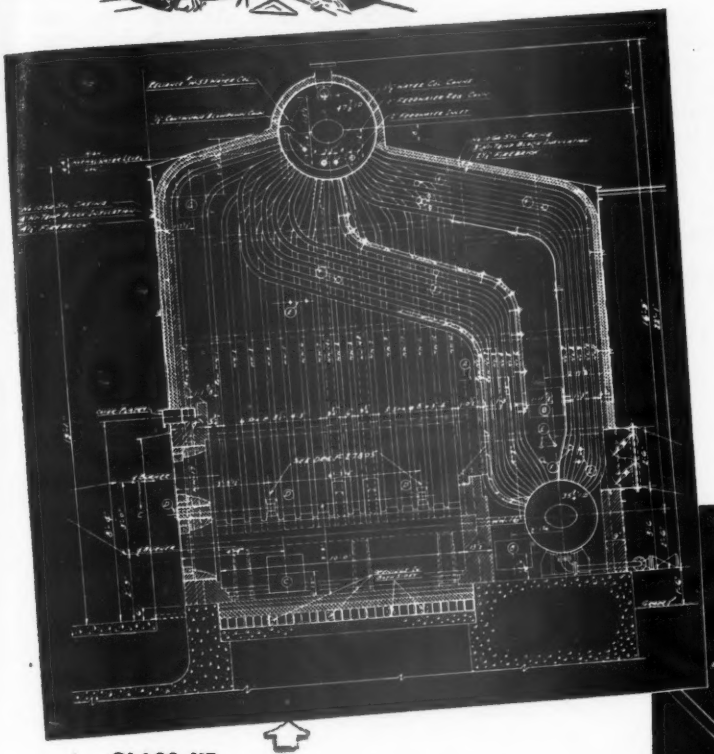

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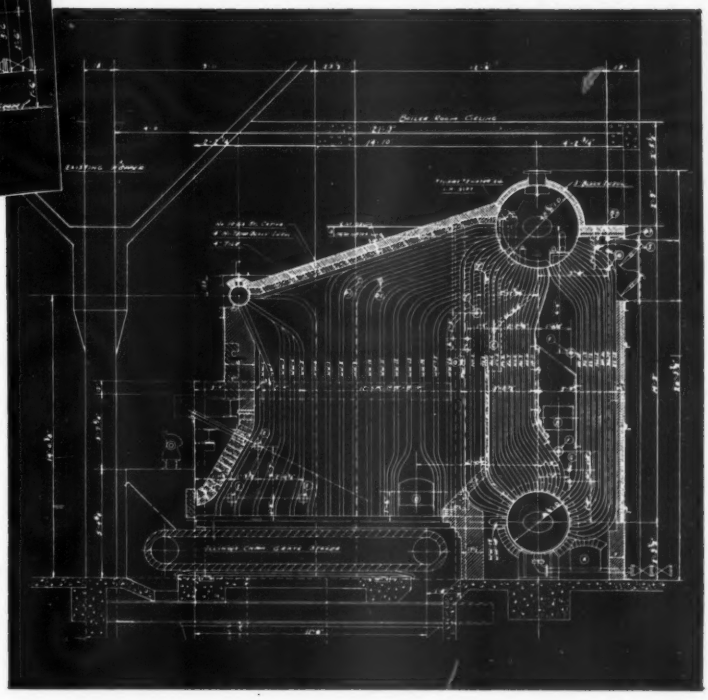

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The results of this work are quite well supported by those of Lambert *et al.* The trend of the data indicates that the value of the compressibility factor at 32 F calculated from the data of Eucken and Parts may be more reliable than that of Baume and Perrot, although the latter is closely supported by the work of Stahrfoss. In any event, the difference in the curve of Fig. 4 would be negligible above 60 F and amount to only 0.07 per cent at 32 F.

Propane (Fig. 5). A great deal of fragmentary data on the compressibility of propane was available. Bottomley *et al*[9] and Casado *et al*[10] determined the compressibility coefficient A in the vicinity of 70 F. Cox[12] reported a value of the density at 104 F and 745.6 mm Hg transmitted to him by Professor Lacey; the compressibility factor at one atmosphere was computed from this value by assuming a linear compressibility isotherm. Kemp and Egan[19] made determinations of the molal volume at 77 F and in the vicinity of one atmosphere and reported their results as a density at 77 F and one atmosphere. Jessen and Lightfoot[16] investigated at "pV vs. p" isotherms at 32 F and 122 F below atmospheric pressure by the expansion method, obtaining three points from each run. Only one run was made at 32 F, and three were made at 122 F. All four runs exhibit positive curvature, which is definitely not to be expected. Jessen and Lightfoot apparently fitted an equation of the type $pV = a + bp + cp^2$ to their data. Because of the positive curvature, such an

FIG. 4. Compressibility factors of ethane at one atmosphere.

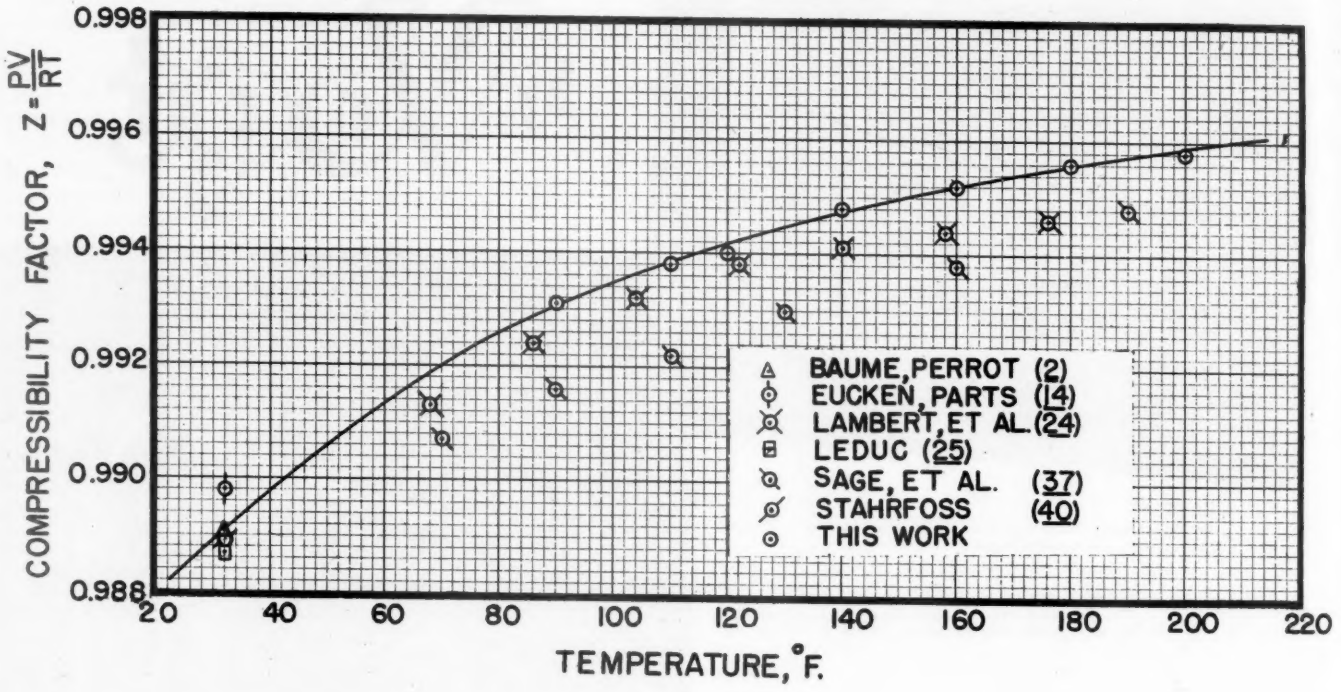
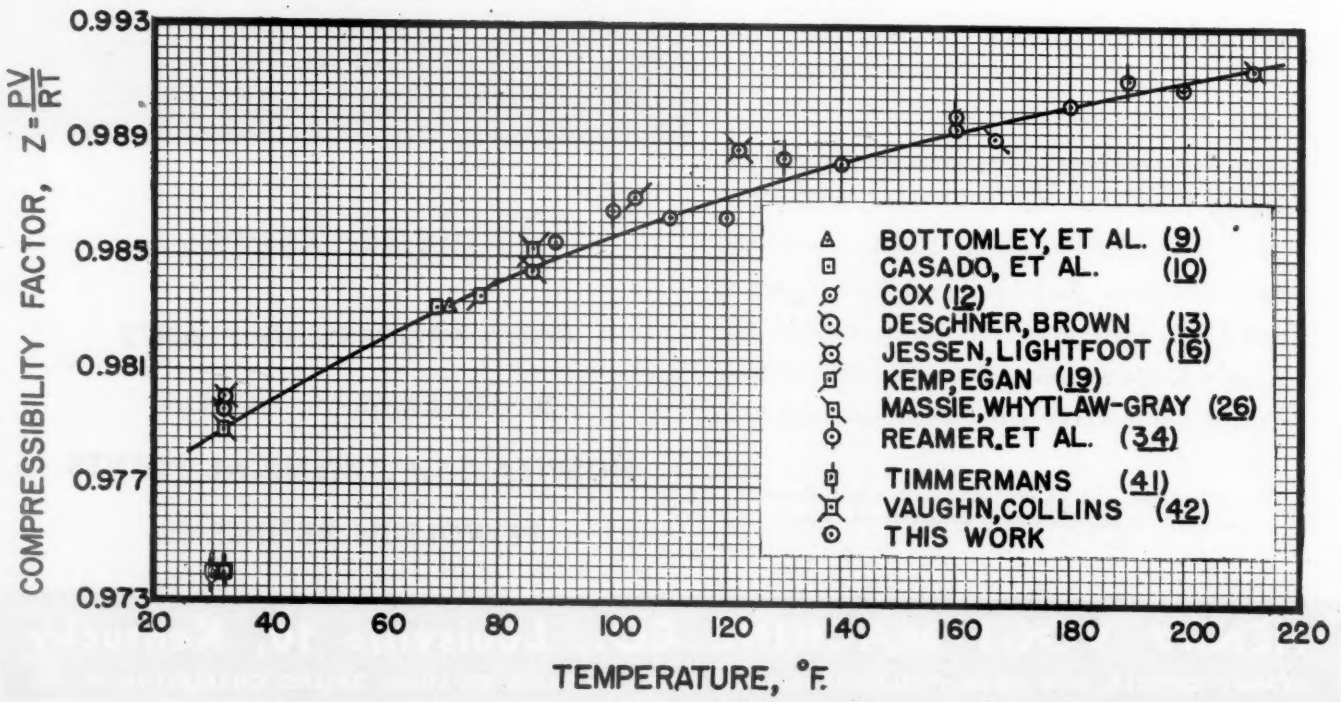


FIG. 5. Compressibility factors of propane at one atmosphere.



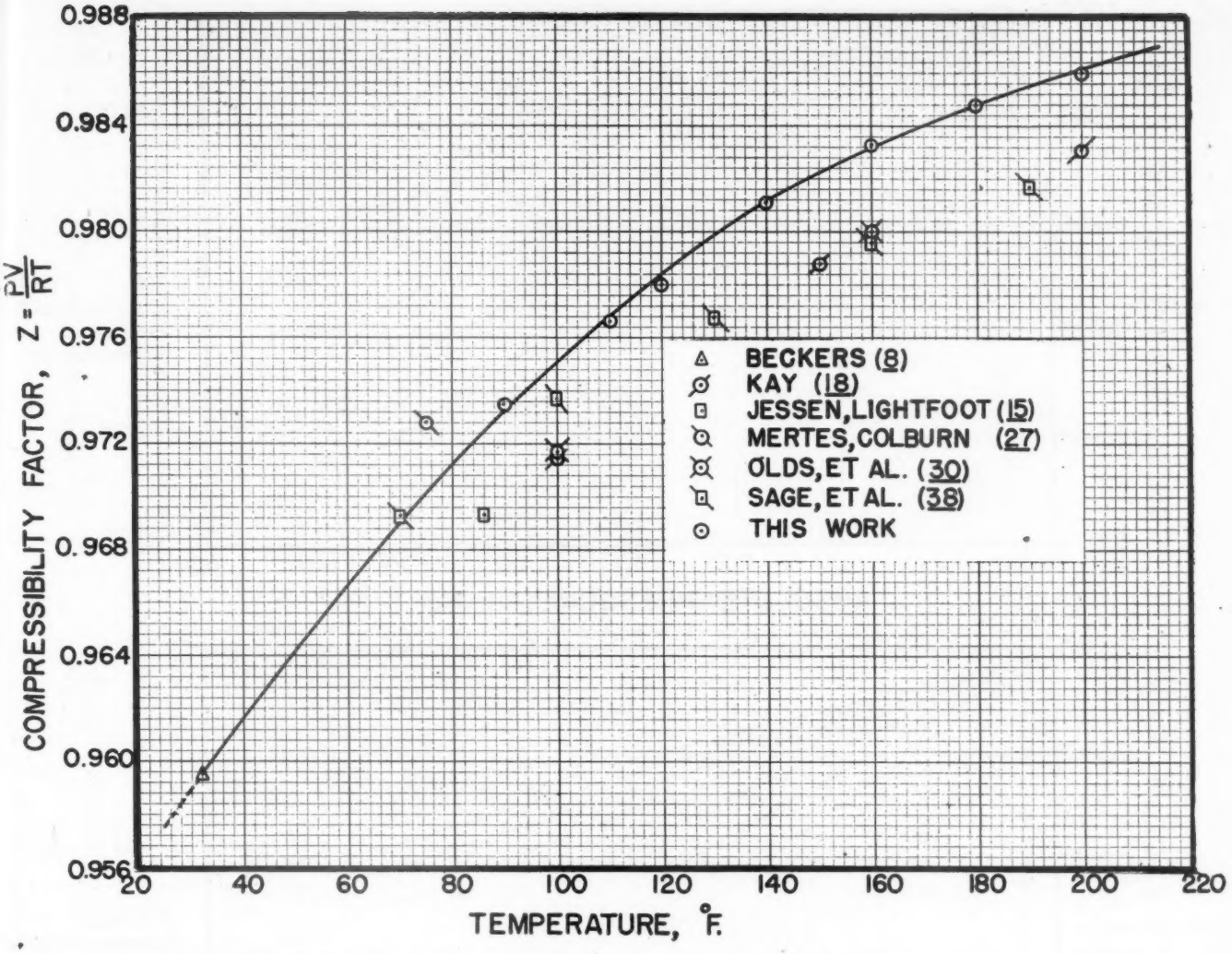


FIG. 6. Compressibility factors of n-butane at one atmosphere.

equation predicts from their data lower values of the compressibility factor at one atmosphere than are found by passing a straight line through the three points of each isotherm. As the deviations of the experimental points from such a straight line are of the order of only 0.03 per cent, this linear method was used to determine the compressibility factors at one atmosphere from the data of Jessen and Lightfoot. Vaughn and Collins[42] made two determinations of the density at 86 F and one atmosphere, with a deviation between the two of 0.11 per cent. The average of their two densities was used to compute the compressibility factor in Fig. 5.

Timmermans[41] determined the normal density of propane, but the reproducibility of his results was poor. Recently, Massie and Whytlaw-Gray[26] reported a much more reliable value. Deschner and Brown[13], in connection with their compressibility investigation up to 120 atmospheres, determined the normal density of their propane. In comparing their value with that of Timmermans, the only one available at that time, they concluded that their propane contained 1.73 per cent ethane. The mean molecular weight computed from this composition was used by them in calculating compressibility factors, the form in which their data were reported. Reference to Fig. 5 indicates that their propane probably had a considerably higher purity; consequently, their values of compressibility factor are low. No correction could be made, however, as only smoothed experimental data were reported.

For purposes of comparison, the data reported by Reamer *et al*[34] in their compressibility study up to 10,000 psia are included in Fig. 5. These data were regarded as superseding the earlier data of Sage *et al*[36]. No low-pressure data were reported by Beattie *et al*[5].

The data of this work are very well supported by the fragmentary compressibility data, particularly at lower temperatures. At the higher temperatures, the trend is the same as that of the data of Reamer *et al* and of Deschner and Brown, and the agreement is surprisingly good.

Normal Butane (Fig. 6). Unfortunately, very little low-pressure data are available for normal butane. Beckers[8] obtained the normal density in a very careful investigation, determining the density at three sub-atmospheric pressures and extrapolating to atmospheric pressure. The reported values of pV at zero pressure and at one atmosphere, which Beckers obtained from extrapolation by the method of second differences, lead to a compressibility factor at one atmosphere of 0.9601. Calculation of the compressibility factor from the reported value of the normal density leads to a value of 0.9592. If Beckers' data are plotted as "pV vs p" and the isotherm drawn linearly below a pressure of 510 mm Hg, a compressibility factor of 0.9595 results. This last value is the one presented in Fig. 6.

Mertes and Colburn[27] reported a compressibility factor of 0.9728 at approximately 75 F and one atmosphere. Because of the approximate nature of this value, it cannot be given too much significance.

Jessen and Lightfoot[15] investigated the "pV vs p" isotherms at 86 F by the same method used for propane[16]. As in the case of propane, positive curvature was indicated by the results of all five runs made. The deviations of the points from a straight line, however, were of the order of only 0.02 per cent; consequently, a linear extrapolation of the data was used, as was done with their propane data, to determine the compressibility factor at one atmosphere. Jessen and Lightfoot[16] have also re-

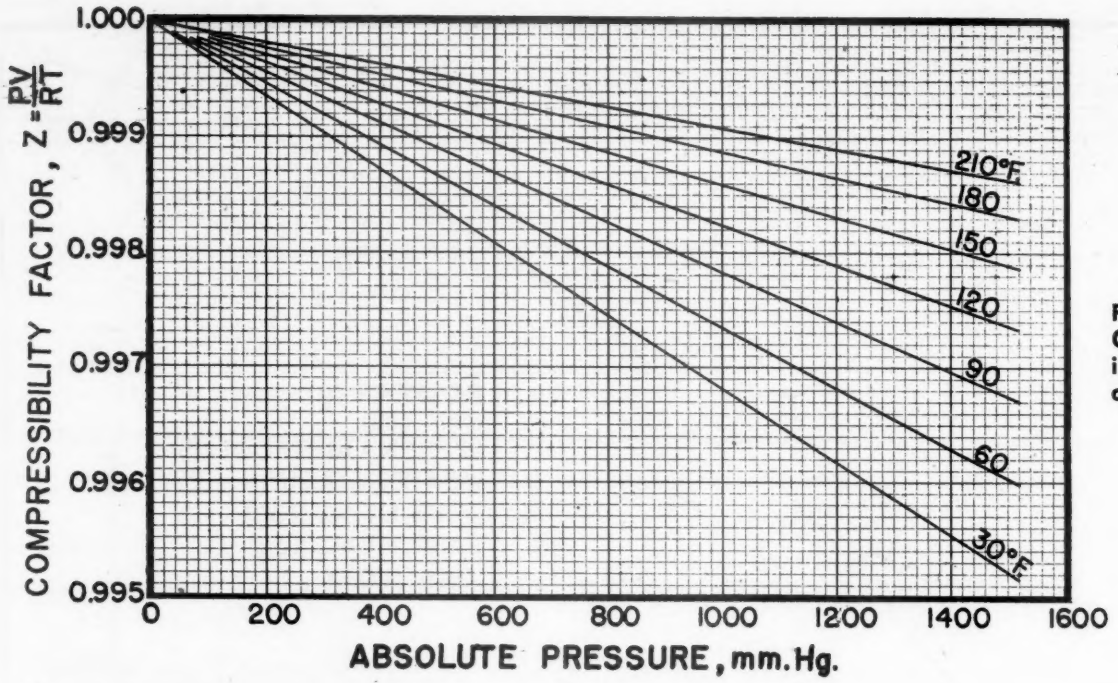


FIG. 7. Compressibility isotherms of methane.

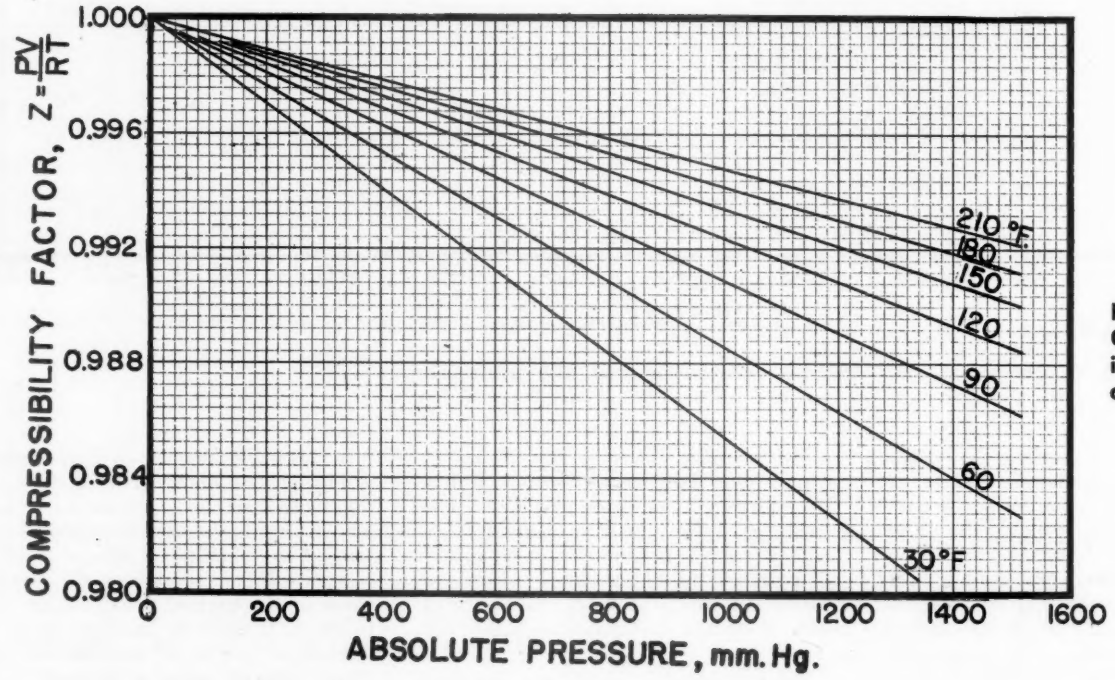


FIG. 8. Compressibility isotherms of ethane.

ported their results with isobutane and normal pentane. With the exception of a few of the runs on isobutane, all of the experimental isotherms exhibit positive curvature, the curvature being very pronounced and presumably beyond the limit of experimental error for normal pentane. Even a linear treatment of the data on these hydrocarbons gives compressibility factors that are appreciably lower (0.4 per cent or more) than those reported by others. In view of these facts, it is believed that the data of Jessen and Lightfoot are not reliable.

Kay[18] presented in the form of smoothed isometrics the results of a study of fifteen compressibility isotherms in, according to that author, both the high- and low-pressure regions. No pressures were tabulated, however, much below two atmospheres and were reported only to the nearest 0.1 psi. Compressibility factors calculated from these smoother isometric data were consequently not isothermally smooth. As no other alternative was available, the compressibility factors up to a pressure of approximately 42 psia were extrapolated linearly to zero pressure, the values of "z" at one atmosphere being read from these linear isotherms.

The data reported at one atmosphere by Sage *et al*[38] in their work up to 3000 psia, and by Olds *et al*[30] in their work up to 10,000 psia are included in Fig. 6. Beattie *et al*[6] reported no values at low pressures.

The work of Beckers at 32 F correlates well with the results of this investigation. The data of both Mertes and Colburn and Jessen and Lightfoot deviate from the curve drawn in Fig. 6 by about 0.3 per cent. For reasons already explained, however, neither of these values are considered to be very reliable. The extrapolation of the curve in Fig. 6 to temperatures below 31 F, the approximate value of the normal boiling point, is justified by the fact that, as previously pointed out, this figure may also be regarded as representing a plot of (1 – A) vs. temperature.

Smoothed Compressibility Isotherms

The compressibility factor isotherms of methane, ethane, propane, and normal butane over the temperature range of 30 F to 210 F are presented in Figs. 7, 8, 9, and 10. These isotherms were drawn as straight lines from $z = 1$ at $p = 0$ through the value of z at one atmosphere (760 mm. Hg) read from

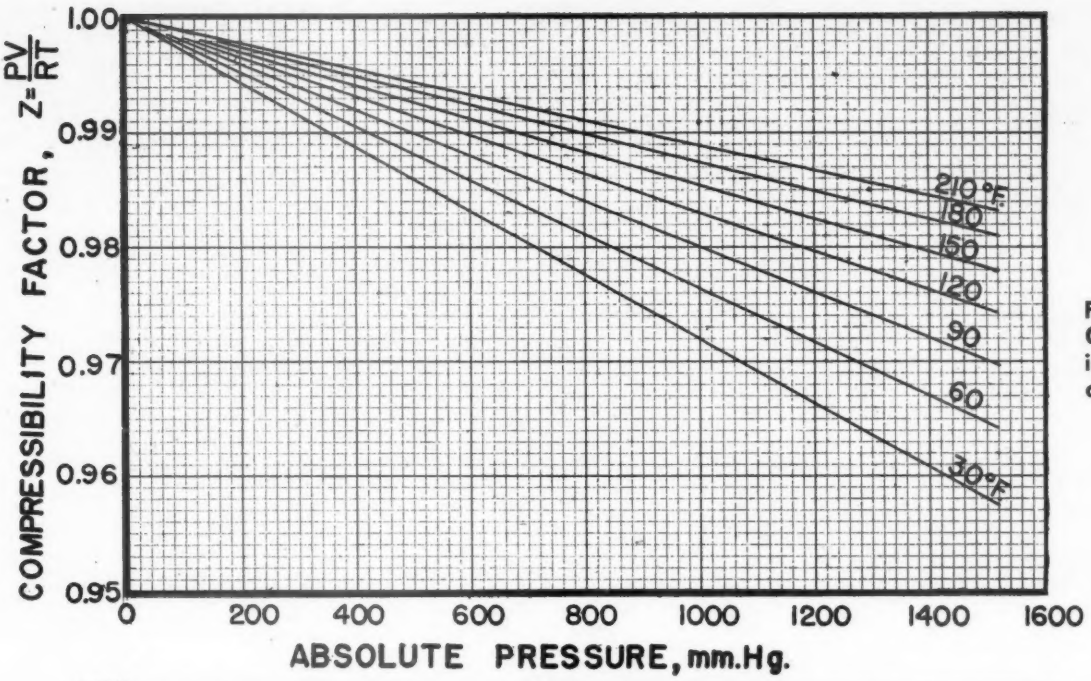


FIG. 9. Compressibility isotherms of propane.

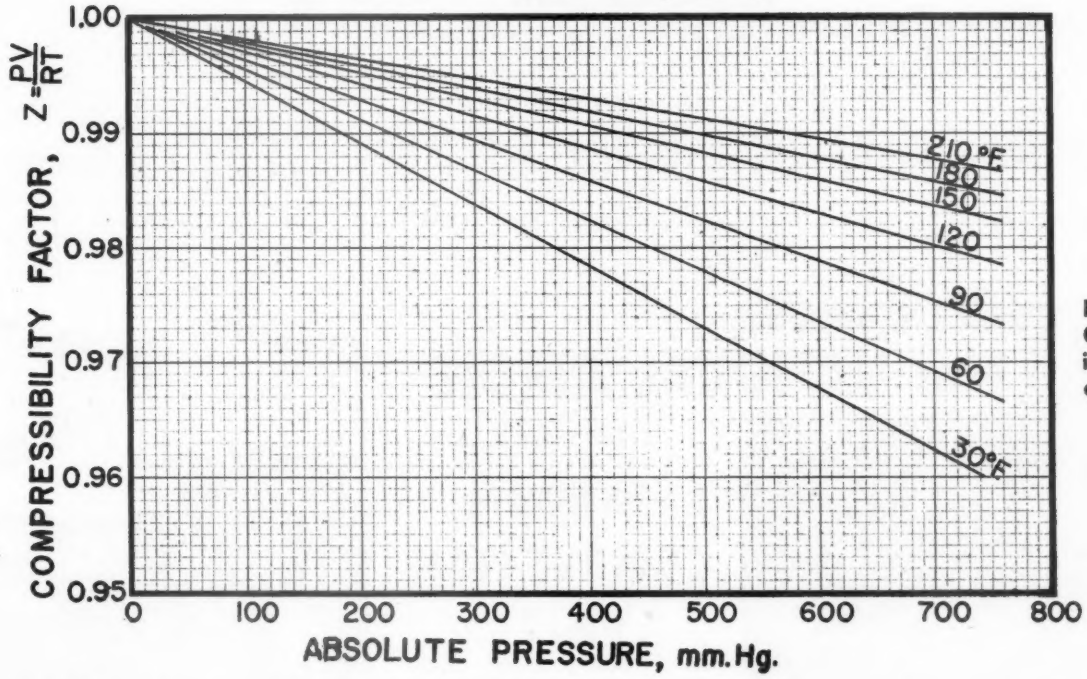


FIG. 10. Compressibility isotherms of n-butane.

the curves of Figs. 3, 4, 5, and 6. It is believed that the representation of the methane isotherms as being linear up to a pressure of two atmospheres is amply justified. No evidence of curvature within the limits of experimental accuracy was found in this work for ethane up to pressures greater than 1400 mm Hg. Although the experimental pressures for propane did not generally exceed 1000 mm Hg, the extremely small deviations from linearity found by Bottomley *et al*[9] at 71 F up to 800 mm Hg and the lack of any evidence of curvature in this work both indicate that a negligible error results from a linear extrapolation to a pressure of two atmospheres. For normal butane, on the other hand, Beckers[8] found a slight curvature in the isotherm at 32 F, and the maximum pressure of slightly less than 800 mm Hg in the present work does not permit any prediction of linearity to a pressure of two atmospheres. Consequently, the isotherms of normal butane in Fig. 10 have been drawn only to a pressure of one atmosphere. It is believed, however, that no serious error would be introduced by a linear extrapolation of the isotherms above 90 F to pressures as high as 1200 mm Hg. The 30 F isotherm of normal butane has been terminated at the vapor pressure corresponding to that temperature[32].

Compressibility isotherms of Figs. 7, 8, 9, and 10 are believed to have the following maximum errors in terms of compressibility factors at one atmosphere:

Methane	0.05 per cent
Ethane	0.05 per cent
Propane	0.07 per cent
n-Butane	0.10 per cent

The error in an isotherm is proportional to the pressure. The estimated error in a methane compressibility factor at two atmospheres pressure is twice that at one atmosphere, or 0.10 per cent.

Acknowledgments

The writers wish to express their sincere appreciation to the following companies for their assistance in this investigation: The Texas Company for the research fellowship under which part of this work was done. The Phillips Petroleum Company for the donation of the hydrocarbons. The Gulf Oil Corporation for the mass-spectrographic analyses of the pure-grade hydrocarbons.

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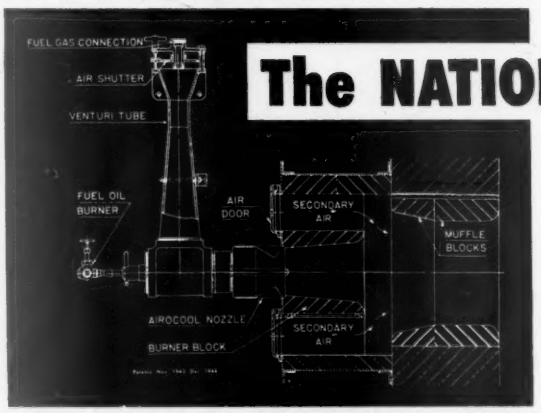

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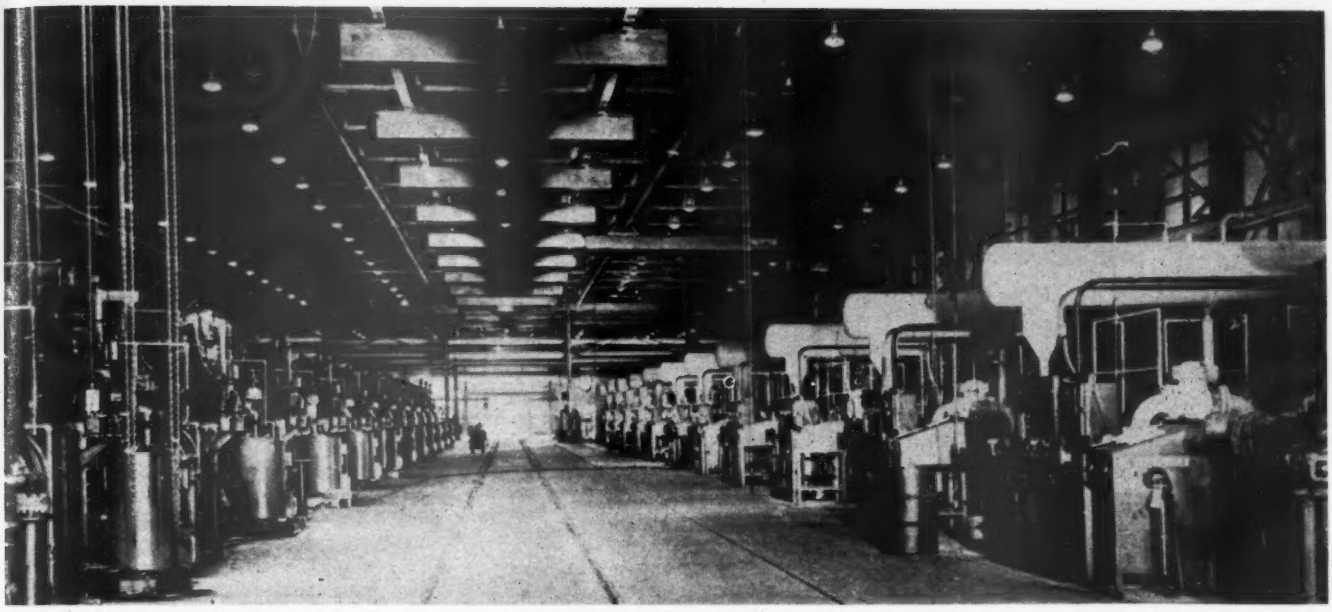

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PETROCHEMICALS FROM WATER GAS

PART 2—Details of water gas conversion; the ammonia and methanol syntheses

PETER W. SHERWOOD*

As originally received from the gasifier, the carbon monoxide-hydrogen ratio varies widely, depending on the process and the fuel employed. Table 1 lists some typical CO/H_2 ratios obtained in a number of water-gas-making processes.

Only in isolated instances do these analyses coincide with the dictates of the synthesis process for which the water gas is to serve as raw material. Table 2 lists ratios considered optimum for a number of major petrochemical processes.

Adjustment of the CO/H_2 ratio in the delivered water gas is therefore essential in the majority of instances. In some cases, this can be accomplished by judicious mixing of two gas streams whose CO/H_2 ratios will supplement each other. In other cases, adjustment must be made either during the reforming stage or by the operation of a water gas conversion stage in the course of which carbon monoxide is reacted with steam to form hydrogen and carbon dioxide.

TABLE 1. CO/H_2 ratio in some water gas processes.

Process	Fuel	Oxygen	Temperature, F	CO/H_2
Steam reforming	Methane	No	1380	.245
Steam reforming	Propane	No	1500	.265
Partial combustion	Methane	Yes	1600	.35
Bureau of Mines externally heated gasifier	Subbit. coal	No	1805	.52
Blue-gas generator (Kerpely-type)	Coke	No	1820	.90
Blue gas generator (Kerpely-type)	Coke	Yes	—	1.75
Koppers-Totzek	Bit. coal	Yes	2192	1.0
Koppers-Totzek	Brown coal	Yes	1832	.78

As will be seen later, water gas conversion is normally carried out at fairly low temperatures (not exceeding 925 F). Under these conditions, equilibrium conditions favor low CO/H_2 ratios. Little can be accomplished by trying to convert hydrogen with economically tolerable amounts of carbon dioxide at such temperatures for the formation of carbon monoxide. The water gas conversion stage is thus useful mainly for decreasing the carbon monoxide/hydrogen ratio.

EXCLUSIVE

If the synthesis calls for high CO/H_2 ratios, the proper place for adjustment is therefore the primary gasification stage, which is carried out at high temperatures. If necessary, the feed gases may be supplemented by the addition of carbon dioxide, which will gasify the fuel in a manner analogous to the action of steam. Moreover, at the high temperatures involved in this stage, there will be a pronounced shift to the left-hand side of equation (1).

$$CO + H_2O = CO_2 + H_2 \quad . \quad . \quad . \quad (1)$$

In the great majority of cases, adjustment of the water gas composition must,

*Chemical Engineer, Pittsburgh, Pa.

TABLE 2. Optimum CO/H_2 ratio for some syntheses.

Process	CO/H_2
Ammonia synthesis	0 (i.e., no CO should be present)
Coal hydrogenation	about 0
Methanol synthesis	.45—0.50
Fischer-Tropsch synthesis (Cobalt catalyst)	0.50
Fischer-Tropsch synthesis (Iron catalyst)	0.50—1.80 (depending on operating variables)
OXO process	1.00
Synol process	1.43

however, be in the direction of a lower carbon monoxide/hydrogen ratio. The favored method for accomplishing this objective is to react carbon monoxide with steam in accordance with equation (1), operating at suitably low temperatures that will favor a shift of this reaction to the right-hand side of the equation.

Commercial Methods of Water Gas Conversion

Fig. 1 shows the effect of temperature on the equilibrium constant involved in the reversible reaction (1). Here is a quantitative measure of the extent to which the reaction is displaced toward the left-hand side with increasing temperature. Where the objective of the conversion is to produce hydrogen, it is seen to be desirable to carry out the reaction at the lowest feasible temperature in order to minimize the excess steam requirements. By way of illustration, we may consider steam consumption in the conversion of a gas mixture of equal volumes of hydrogen and carbon monoxide to make gas containing 1 volume per cent carbon monoxide. If the reaction is carried out at 700 F, it is necessary to employ a steam-to-gas ratio of 3.5:1. At 930 F, on the other hand, it is necessary to raise this ratio to 10.5:1.

The limit to operation at low temperatures is set by the small reaction velocities that prevail under such conditions. If the reaction were carried out at, say 650 F, a tremendous reaction space would have to be provided in order to achieve the necessary contact time. In order to permit an economically sensible design at the lower temperatures, it becomes necessary therefore to speed the progress of the reaction catalytically.

Catalysts employed industrially for the water gas shift reaction are based mostly on iron oxides with various promoters. Although catalysts of this type must be operated at higher temperatures than the more active cobalt and nickel catalysts, they are less susceptible and sensitive to sulfur poisoning. (The use of cobalt-copper catalysts is suitable for sulfur-free water gas such as may be obtained from catalytic methane reforming operations described in Part 1 of this article series. Operation of such a catalyst has been reported for at least one installation.)

Iron catalysts are subject to a lower temperature limit because of their tendency to promote the deposition of carbon according to the equation:

$$2CO = C + CO_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This reaction is particularly pronounced at temperatures below 880 F. It tends to reduce the effective yield of hydrogen and to destroy the activity of the catalyst. Another limitation is encountered when the conversion is operated under pressure. In that case, iron catalysts have a tendency to promote the methanization of carbon monoxide. By proper compounding of the catalyst it is possible to reduce the lower temperature limit set by equation (2) and to minimize the tendency toward methanization. Catalyst compositions employed in various commercial installations have been reported by the author elsewhere (9).

Although large amounts of hydrogen sulfide have a temporary poisoning effect on iron catalysts, small quantities are handled by them with ease. In some plants, the water gas conversion catalyst is actually used as an essential part of the sulfur purification system, serving to retain organic as well as inorganic sulfur, and thus to protect the synthesis catalyst. This method of sulfur removal is inefficient, however, and represents only rarely the most economic operating technique.

The temperature range usually selected for iron-catalyzed water gas conversion is between 750 and 925 F. By operating at the higher temperatures, a smaller reactor space is generally sufficient to effect the conversion. On the other hand, such operation means greater steam consumption and lower fuel economy. The final temperature selected is generally determined by economic considerations and depends, to a certain extent, on the activity of the catalyst employed, and on the desired product purity. If the purity of the hydrogen is not too critical, a single-stage conversion may be sufficient. In that case, the greatest possible use should be made of this stage by operating at the lowest feasible temperature. Certain applications—notably the hardening of vegetable oils—require a gas so low in carbon monoxide that single-stage operation may be economically unadvisable. In that case, the extent of conversion per stage is not quite so critical and a higher temperature may actually be economically sound because it will reduce the required catalyst volume.

During recent years, pressure conversion has achieved some popularity. This mode of operation results in greater throughput per unit reactor space, but has the disadvantage of causing some corrosion difficulties and therefore requiring the use of alloy steels. The prime advantage of pressure operation is a saving in compression charges if the product is to be used at elevated pressures. The reason for this is the formation of two volumes of gaseous products for each volume of carbon monoxide reacted (no compression charges are incurred in the production of high-pressure steam, the other reactant). Com-

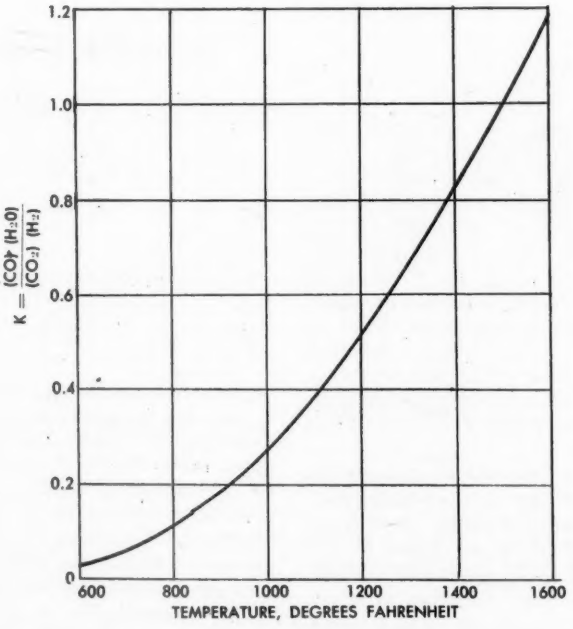
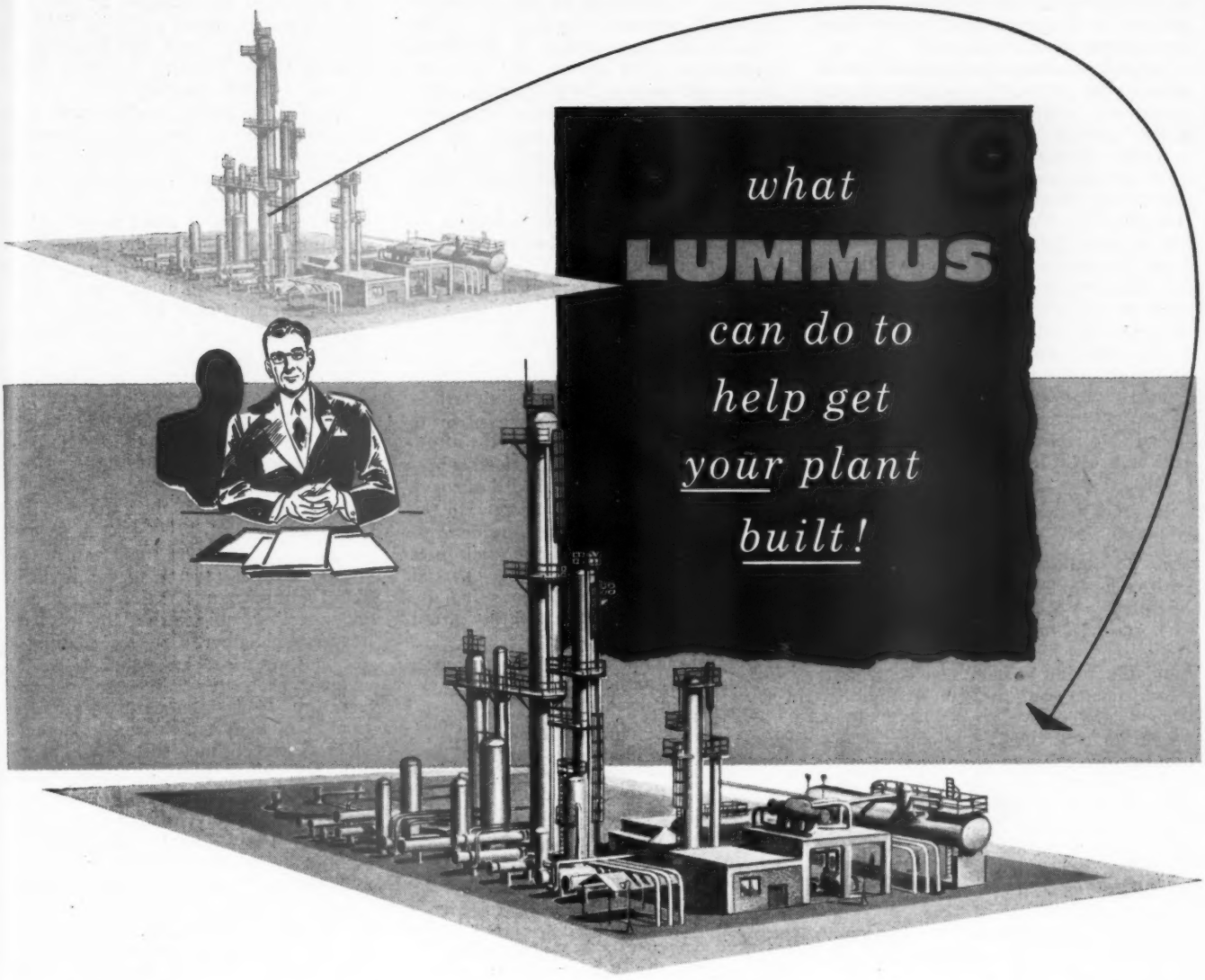


FIG. 1. Water gas equilibrium.



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pression charges are therefore reduced effectively if the reactants rather than the products are compressed.

A saving in steam consumption can be shown for pressure operation of the water gas conversion. The amount of steam carried out of the system is, roughly, inversely proportional to the pressure. By operating at elevated pressures, it is therefore possible to reduce the amount of steam and heat losses very appreciably.

If the demands on hydrogen purity are high, considerable steam savings may be achieved by operating the water gas conversion in two or three successive stages. The reason for the favorable effect of several stages can be readily seen from thermodynamic considerations. When equilibrium conditions are established, the components of the reaction will be present in the following ratio:

$$K = \frac{(CO)\,(H_2O)}{(H_2)\,(CO_2)}$$

Two possibilities exist to increase the hydrogen content of the equilibrium mixture: (a) More steam may be added, (b) carbon dioxide may be removed. If the required hydrogen purity is very high, the point is soon reached where steam consumption in a single stage becomes intolerably great. It is then proper to cool the gas product of the first conversion stage, remove all or most of the carbon dioxide by scrubbing, and continue the conversion in a second stage. It has been calculated that the production of 98 per cent hydrogen by the conversion of pure carbon monoxide at 850 F requires 6.37 cu ft steam/cu ft carbon monoxide in single-stage operation. The same effect can be achieved with only 2.23 cu ft steam in two-stage conversion.

Methods of carbon dioxide removal from the product gas involve the use of high-pressure water or of alkaline solutions as described in Part 1 of this series.

Unconverted carbon monoxide may be removed from the product by scrubbing with ammoniacal cuprous carbonate solutions at 4000-4500 psig. This solution is regenerable by the application of heat and vacuum and the evolved carbon monoxide may be recycled to the water gas conversion stage. Other cuprous salts have been employed successfully for carbon monoxide scrubbing at 375 psig and 25 F. In neither case will the product contain less than 0.5 per cent carbon monoxide. Further reduction of carbon monoxide content can be accomplished by such means as catalytic methanization. Small amounts of carbon monoxide can be removed from (low-pressure) hydrogen by low-temperature scrubbing with liquid nitrogen. This method is highly effective but is economically limited to a few special installations.

Production of Ammonia

Strictly speaking, synthetic ammonia is a secondary product of water gas, being contingent on the intermediate production of hydrogen by the previously discussed conversion process. Its inclusion in this presentation is considered justified in view of the fact that ammonia synthesis is historically the oldest and economically the most important chemical consumer of water gas. In 1949, 1,564,000 tons of anhydrous ammonia were manufactured in the United States by synthetic methods. At least 80 per cent of the total hydrogen requirements for this production were derived from water gas.

The synthesis is based on the equilibrium reaction (3):

$$N_2 + 3\,H_2 = 2NH_3 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Raw material is a mixture of nitrogen and hydrogen in theoretical proportions (ammonia yield is quite sensitive to maintenance of the correct ratio of reactants in the feed gas). The feed is produced by mixing hydrogen with nitrogen (from an air liquefaction plant) in the correct proportions, or by supplementing water gas with nitrogen-rich producer gas (generated by the partial combustion of a carbonaceous fuel by means of air) and converting the mixed gas make.

Controlling variables in the execution of ammonia synthesis are:

- Pressure
- Temperature
- Catalyst
- Method of cooling
- Ratio of reactants
- Presence of inert gases
- Recycle ratio (vs. number of reaction stages)

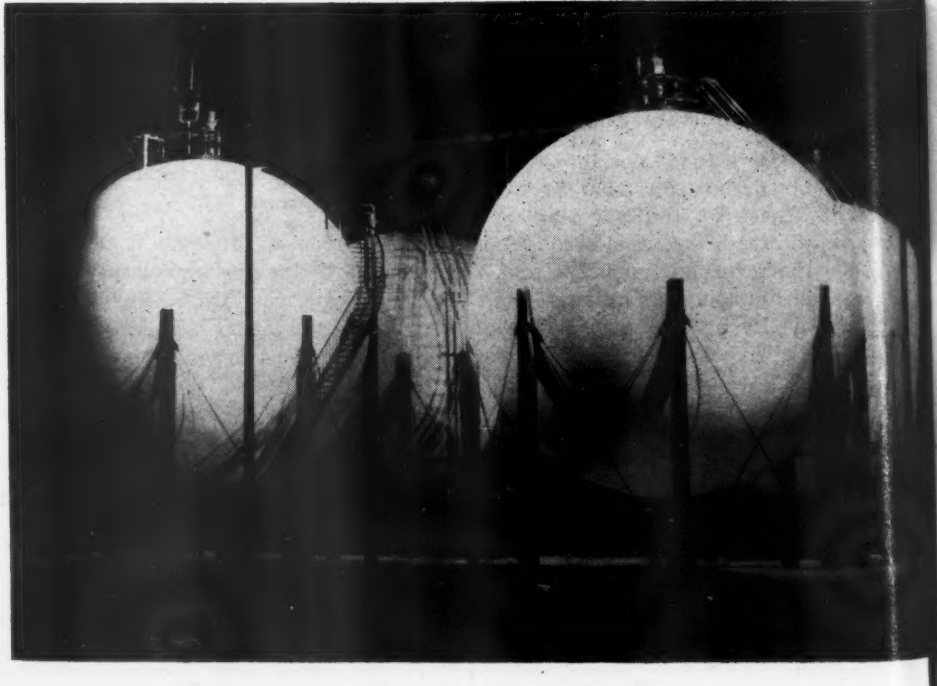
A study of equation (3) shows a marked decrease in reaction volume in the course of the synthesis. From thermodynamic considerations, it is clear that a favorable equilibrium can be promoted by operating at very high pressures. In actual practice, synthesis pressures vary from 100 atmospheres (Mont Cenis process) to 1000 atmospheres (Claude process).

Proper operating temperatures must be selected by an economic compromise, taking account of its effect on reaction kinetics and on possible conversion per pass. An increase in temperature has a markedly favorable effect on the rate of reaction, but it tends to displace the equilibrium toward the left-hand side of equation (3). Ideal execution of the reaction would take advantage of the favorable effect on reaction rates in the beginning of the conversion by operating the reactor inlet at high temperatures, and would then lower the temperature progressively to attain a good equilibrium position at the reactor outlet. In practice, this procedure can only be approximated because of the highly exothermic nature of the reaction (1390 BTU/lb NH_3 at 1180 F). A favored method for adjusting temperature conditions in the reactor to approximate this thermodynamic optimum is to provide cooling coils inside the catalytic reaction chamber. Cooling medium is the incoming feed gas which is, in this manner, preheated to reactor inlet temperature. Typical temperature distribution in a modern (Fauser) reactor is 1020 F at the inlet and 840 F at the chamber exit. A maximum temperature of 1090 F is reached at a point very close to the reactor inlet.

An alternate commercial method of cooling the reaction system is to inject cool synthesis gas at various points in the catalyst bed. This procedure has the advantage of simplifying reactor design, but it has inherent thermodynamic defects that are beyond the scope of the present paper.

Regardless of operating conditions,

Ammonia holders. *Courtesy Lion Oil Company.*



complete conversion per pass cannot be achieved because of equilibrium limitations. Depending on the reaction pressure, a conversion per pass of 10 to 30 per cent is taken. The reaction products are then removed from the reaction gases which are then recycled and mixed with the fresh feed gases or (in the Claude process) converted in successive reaction stages. The separation of ammonia from the gases may be accomplished advantageously by condensation, or if desired, by absorption in water under pressure.

Reference has already been made to the very important effect of nitrogen/hydrogen ratio on the ammonia yield. If the feed gas should deviate from theoretical composition, not only will the conversion-per-pass be decreased, but the deleterious effect will actually be cumulative as the ratio of the recycle gases becomes progressively less advantageous.

Water vapor, carbon dioxide, and sulfur compounds are poisons for most ammonia synthesis catalysts and their absence must be assured. At the same time, severe economic losses may be occasioned by the presence of such apparently inert components as methane. The difficulty here rests in the progressive accumulation of these inerts as the gas is recycled. As a result the partial pressure of the reactants will gradually be reduced to the point where conversion per pass is reduced below the economically feasible minimum. At the same time, the reaction rates are decreased below the point expected from a mere consideration of lowered partial pressure (This is due to the reduction of useful molecular collisions caused by interference by the inert molecules present in the system). Eventually, a point is reached, where it becomes necessary to bleed off a portion of the recycle gases in order to keep the concentration of inerts within permissible bounds. Along with the inert components, useful synthesis gas is withdrawn from the system with a corresponding loss in ammonia yield.

Inert-rich gases can be handled more successfully in multi-stage than in recycle operation. The effect of inert components is not serious in the early stages which may accordingly be kept small. By adjusting later stages to the increasing presence of inert components (due to the decrease in useful synthesis gas), it becomes possible to minimize yield losses. It must be pointed out, however, that thermal efficiency of multistage ammonia processes is relatively low. The method is therefore only suitable where it is possible to obtain a high conversion per contact stage, as is the case in operation at very high pressures. This type of operation has an additional favorable effect in that high pressures promote the dissolution of inert gas in the liquid reaction products and thus minimize its accumulation in the reaction gas.

Selection of the proper catalyst is essential if industrially bearable space-time yields are to be attained around 835-1150 F, which represent the economically limiting temperatures (as determined by possible conversion per pass and demands on the converter materials of construction). The most active catalysts (platinum, tungsten, and molybdenum) are not in commercial usage because of their high price. Instead, industrial practice has been concentrated on the use of iron catalysts. A favored method of producing a highly active catalyst is to reduce magnetite (Fe_3O_4) by means of hydrogen at relatively low temperatures. This catalyst has per se a short active life, presumably because of crystallization processes that change its surface structure. It is therefore necessary to incorporate promoters such as magnesium chromite or aluminate in the catalyst formulation.

Reduced iron oxides are the basis for all but one commercial ammonia synthesis catalysts, although the actual formulation with regard to promoters varies widely. The lone exception is found in the Mont Cenis process, which is operated at relatively low pressures and temperatures (100 atmospheres and 750-790 F), and which therefore necessitates highly active catalysts. For this purpose, complex iron cyanide salts are provided in the converter. It has, however, been determined that the catalyst is readily changed to metallic iron at operating conditions. Quite possibly the high activity of this catalyst is due to its strong tendency to form unstable iron nitrides that might serve as intermediates in the synthesis of ammonia.

The first commercial ammonia synthesis process, due to Haber and Bosch, is still the basis for the production of more than 50 per cent of the world's ammonia production. Five other processes, all of which differ from the Haber-Bosch process only in degree, have found commercial favor. The United States has concentrated on the Haber-Bosch and Nitrogen Engineering Corporation processes, while the Mont Cenis synthesis supplements the much more important Haber-Bosch process in Germany. In the French ammonia industry, the Claude and Casale processes have found particular favor. The only other significant ammonia process, due to Fauser, has been practiced primarily in Italy where it originated.

The following table summarizes reaction conditions in these processes:

Process	Pressure	Temperature	Conversion per pass, %	Cycle
Haber-Bosch	200 atm.	840—930F	10—20	Recycle
Claude	900—1000atm.	1200 F	30—35(per stage)	Multistage
Casale	600—900 atm.	930 F	20	Recycle
Fauser	200—300 atm.	830—1110 F	10—25	Recycle
Nitrogen Eng. Corp.	300 atm.	850—950 F	20—22	Recycle
Mont Cenis	100 atm.	750—790 F	10—25	Recycle

The various processes offer the following main distinguishing features (as compared to the Haber-Bosch process):

Claude—higher pressure, multi-stage operation

Casale—Particularly simple and thermally efficient reactor design, higher pressure

Fauser—Special provisions to assure temperature drop from reactor inlet to outlet

Nitrogen Engineering Corporation — Synthesis gas is preheated by means of hot flue gases during start-up. Other processes provide electrical heating in converter for this purpose

Mont Cenis—Low temperature and pressure, particularly active catalyst

These main process differences are, of course, extended by lesser variations in different installations. There is no design uniformity even in different plants operating according to the same basic process.

Production of Methanol

The second-most important chemical outlet for water gas is the high-pressure synthesis of methanol. This process has experienced particularly significant growth during the past few years and is today the basis for the U. S. production of some 518,000 tons methyl alcohol per year.*

$$CO + 2H_2 = CH_3OH \quad . \quad . \quad . \quad . \quad (4)$$

Certain similarities in reaction conditions and ultimate raw material have led to frequent comparisons between the methanol and ammonia high-pressure syntheses. In fact, it is possible to convert an ammonia plant to methanol production at only relatively small cost. There are, however, fundamental differences that determine significantly the execution of each reaction.

The high-pressure reaction of hydrogen and nitrogen can eventually lead to only one product: Ammonia. Conditions must therefore be adjusted with a view to attaining maximum conversion within the limits of the equilibrium. Reaction kinetic considerations are of secondary importance. The methanol synthesis is, on the other hand capable of yielding appreciable by-products, among which methane, higher alcohols, aldehydes, and acids figure most prominently.

The choice of proper catalyst is therefore quite as important as are temperature, pressure, and contact time. Actually, under normal synthesis conditions, there is a greater tendency for carbon monoxide and hydrogen to combine for the formation of methane than to yield methanol. It is, therefore, not permissible to reach thermodynamic equilibrium. Instead, a catalyst is chosen that will expedite the methanol-forming reaction very much more than it will promote methanization. After optimum conversion has been achieved, further reaction toward achievement of equilibrium is prevented by removing the re-

*1949 figures by U. S. Tariff Commission.

action gases from catalytic contact.

Favored catalysts for the reaction have a mildly hydrogenating action. Zinc oxide in highly active form has found wide application. Usually, it is necessary to incorporate one or two promoters (chromium oxide, aluminum oxide, etc.) into the catalyst formulation in order to maintain long catalyst life.

Other industrially significant catalysts are based on highly activated copper—either alone or in combination with zinc oxide. Copper has the advantage of being more active at low temperatures but it has found only limited application because of its very pronounced sensitivity to sulfur compounds which poison it permanently (while sulfur-poisoned zinc oxide catalysts can be regenerated).

Various methanol installations cover a pressure range of 150 to 1000 atmospheres and temperatures from 480 to 750 F. The highly exothermic nature of the reaction (1220 BTU/lb methanol) necessitates appropriate measures for providing cooling in the reactor. Widely practiced is the injection of cold gas along various points of the converter. Water injection has also been employed, although this will result in lower conversion per pass and consequently higher recycle requirements (another disadvantage is the dilution of the product). The third alternative for reaction cooling is the use of heat exchanger tubes inside the reactor.

Although adiabatic reaction is possible (though not desirable) in ammonia synthesis at highest pressures (Claude, Casale), this approach is excluded from consideration in methanol synthesis. As the temperature rises, conditions become increasingly favorable for methane formation. Being even more exothermic than methanol formation, methanization will result in an even more rapid increase in temperatures and control will eventually be lost over the reaction system. It is therefore quite essential that there is a temperature drop along the path of the reaction gases.

At reaction conditions employed normally in industry, the calculated thermodynamic equilibrium is reached after 15-35 per cent of the synthesis gas has been converted to methanol. In practice, conversion is restricted to considerably lower values in order to minimize the occurrence of side reactions. The condensable products are removed from the reactor exit stream by cooling under pressure and are worked up by distillation. The residual gas is joined by make-up synthesis gas and is recycled to the converters.

As in the case of ammonia synthesis, the presence of inert gases is to be avoided, because of their important effect on the partial pressure of the reactants and because of the yield losses that are associated with large bleed streams necessitated by the presence of significant amounts of inerts.

The presence of carbon monoxide at the drastic conditions of the methanol synthesis imposes special requirements on the selection of construction materials for the converters. Iron, nickel, and cobalt are subject to the formation of carbonyls with consequent loss of metal. At the same time, these metals promote the formation of carbon and carbon dioxide from carbon monoxide and catalyze methanization of the system carbon monoxide-hydrogen. In certain alloys (copper-nickel, high percentage chrome steels), these side reactions disappear and the use of these materials has been proved for converter construction in numerous methanol plants.

An alternate commercial synthesis of methanol is based on the reaction of carbon dioxide with hydrogen that may be carried out by itself or in conjunction with the high-pressure hydrogenation of carbon monoxide.

$$CO_2 + 3H_2 = CH_3OH + H_2O \quad . \quad (5)$$

The reaction has certain advantages if carbon dioxide is available as a by-product of some other process. It is considerably less exothermic than the methanol synthesis previously described and control is therefore simpler.

The process is carried out at pressures and temperatures analogous to those employed for reaction (4). Unconverted gases are recycled to the reactor. Optimum gas composition reaching the catalyst is the theoretical CO_2/H_2 ratio (i.e. a carbon dioxide content of 25 per cent). The recycle gases are, however, depleted in carbon dioxide content (10-15 per cent because part of this gas reacts with hydrogen to form water and carbon monoxide, and because considerable quantities of CO_2 remain dissolved in the condensed product (aqueous methanol). The carbon dioxide content of the make-up gases must therefore be taken at a high enough value to assure the desired CO_2/H_2 ratio in the mix gas entering the catalyst.

Overall yield in the process is somewhat lower than can be obtained in the production of methanol from carbon monoxide, ranging about 80 per cent of theory. The process is particularly suitable for locations where low electric power costs permit the production of hydrogen by water electrolysis, and where a suitable source of CO_2 exists. The need for gasification of carbonaceous fuel is then completely obviated. This type of synthesis is therefore of only secondary interest as a user of water gas.

Some interest attaches to the "low-pressure" synthesis of methanol from water gas by a two-step process. As the method has not attained industrial stature, it is mentioned only briefly in this connection.

The underlying reactions are:

$$CH_3OH + CO = HCOOCH_3 \quad . \quad . \quad (6)$$

$$HCOOCH_3 + 2H_2 = 2CH_3OH \quad . \quad (7)$$

$$\text{Overall: } CO + 2H_2 = CH_3OH$$

Catalyst for reaction (6) is sodium methylate, while a typical Adkins hydrogenation catalyst (copper-chromium-barium oxide) is employed for reaction (7). Overall yields up to 95 per cent have been reported. Maximum pressure in the process is 30 atmospheres. Principal disadvantage is the need for very pure starting gases that can only be procured at considerable purification costs.

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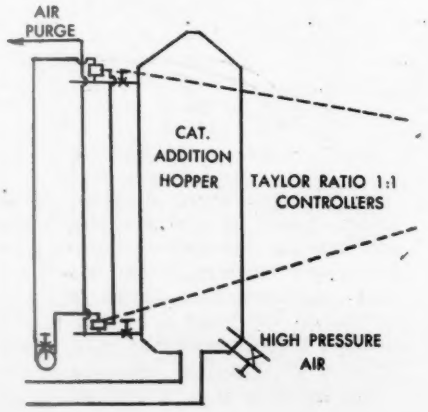
* * *

Part 3 will be published soon.

PLANT AID

Controls on Catalyst Addition Hopper

Catalyst is added to the system in the Fluid catalytic cracking units from a hopper, high-pressure air being introduced as indicated in the drawing to force the catalyst into the unit. Originally the meter lead lines were tied directly to the pressure taps which resulted in plugging these lead lines with catalyst, blowing mercury from the meters when air pressure was applied to charge the catalyst makeup drum. With a booster air relay in each of the two pressure taps each throttles a common air supply to the same pressure at the tap pressure, operating the instrument with throttled air rather than with catalyst-bearing air from the tap. Taylor controllers were installed in the meter lead lines as shown. The relays serve as seals to keep the catalyst out of the lead lines.



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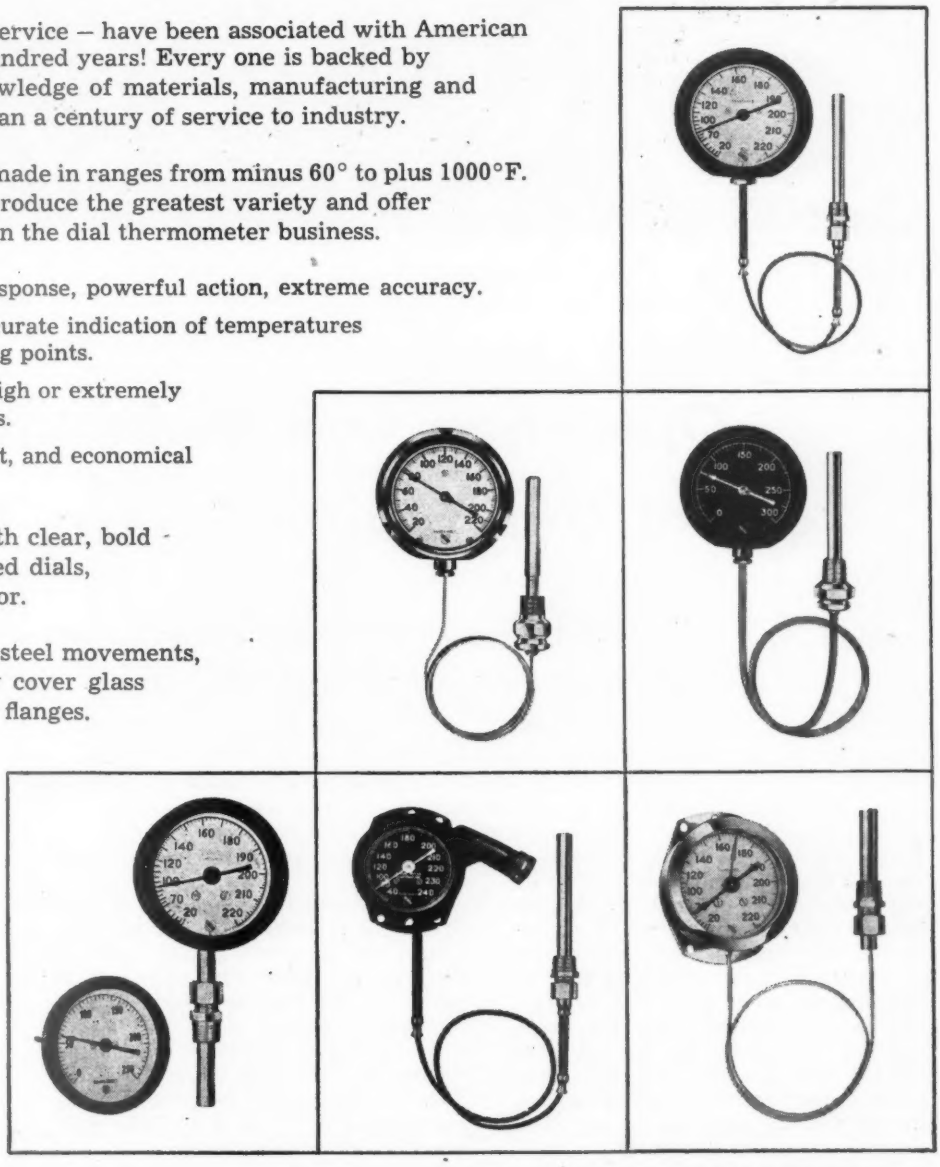

Pictured here are some of the many American Dial Thermometers stocked and sold by leading distributors.

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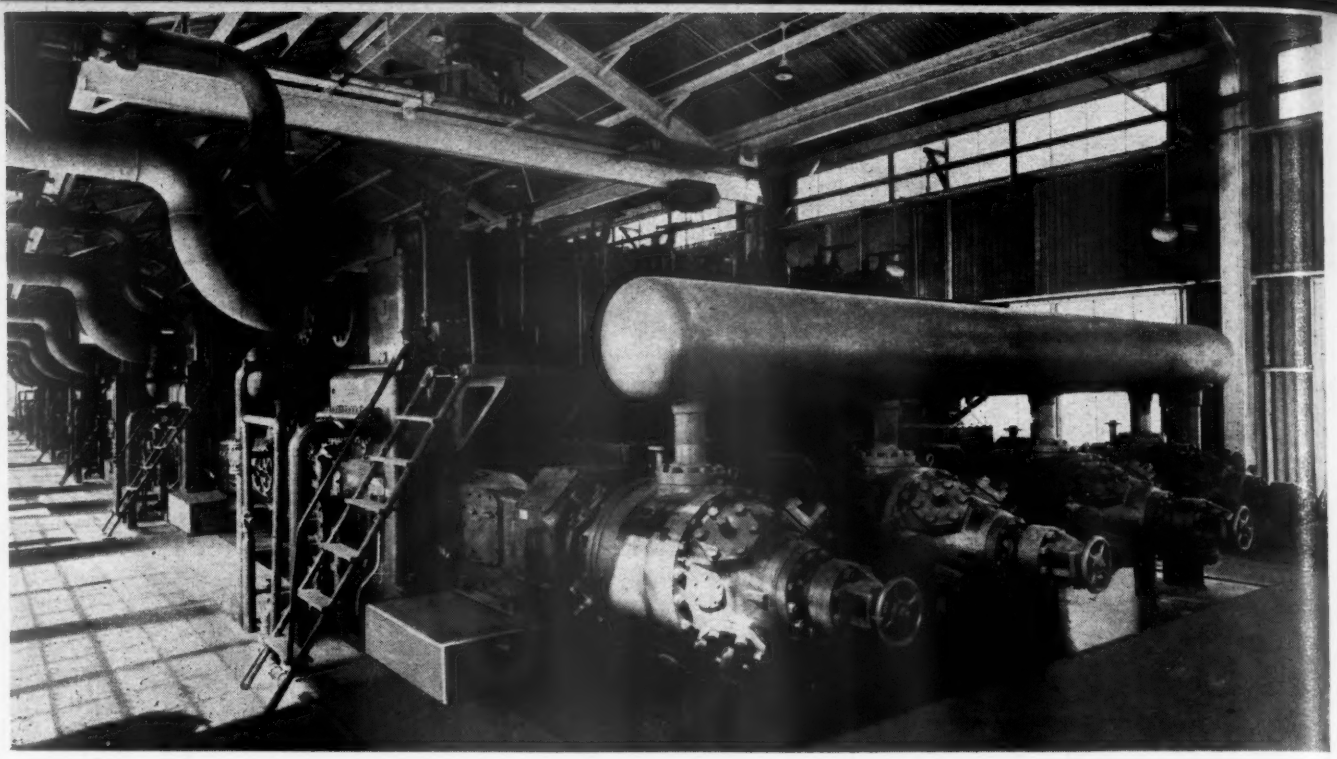


A large multi-unit installation.

P 739.52

Operation and Maintenance of Vertical Gas Engine Driven Compressor*

Systematic inspection and repair programs insure higher efficiency with lower costs, and longer compressor life

JAY B. WILLIAMS† and V. E. FORD†

FROM the date of its introduction, to the oil and gas industries some 15 years ago, the vertical or angle gas-engine-driven compressor was enthusiastically accepted and has since superseded its predecessor, the horizontal unit, in all industries where natural gas is available as an economic fuel. The angle machine is universally used in the natural gas, gasoline, petroleum, and allied industries where several million horsepower are operating in unit sizes ranging from 75 to 2500 BHP.

Through the national emergency, or during the first half of the last decade, there was very little change in design and sizes of equipment available; however, since that time several new models have been introduced that offer many improved design features. Briefly, and by no means complete, here are a few of the additions, refinements and new design features offered by one engine manufacturer. This expansion and development is typical of the vertical gas engine driven compressor industry as a whole.

1. Introduced angle machines in sizes from 1200 to 1600 BHP and later extended the lines to include units as large as 2500 BHP. Previously a 1000 BHP machine was the largest unit of this type available.
2. Added a line of small angle units ranging in sizes from 75 to 330 BHP. These machines were designed to fulfill the demand for a small portable skid-mounted self-contained unit.
3. Increased the engine compression ratio, or compression pressure which has improved the thermal efficiency or lowered the fuel consumption and reduced the engine cooling requirements and exhaust temperatures.
4. Incorporated many improvements and advanced design features, among which are:
   a. Spiral-flow power cylinders and heads for high velocity jacket water circulation and uniform cooling.
   b. Precision type main and connecting rod bearings that give much longer life and minimizes the time necessary for making replacements.
   c. Parco-Lubrized power cylinders and pistons. Parco-lubrizing greatly reduces the possibility of cylinder scuffing during the break-in period on new machines and also rust proof spares.
   d. Induction hardening of steel cylinder liners, piston rods, and valve seats for increased life with minimum maintenance.
   e. Three piece power pistons with cast steel heads and cast iron skirt for more efficient oil cooling and free uniform expansion.
   f. Air cooled compressor cylinders for low ratio gas transmission service.

Organizations familiar with this equipment have long recognized that a properly planned and recorded mechanical maintenance program, diligently executed and co-ordinated with operations, is a prime factor in assuring economic, trouble-free service. Furthermore, they realize that the machines can be kept in

*Presented at NGAA Panhandle Plains regional meeting, Amarillo, Texas.

†Clark Bros. Company, Inc., Tulsa, Oklahoma.

DU PONT REG. U.S. PAT. OFF.

PETROLEUM CHEMICALS DIVISION

NEWS

DU PONT REG. U.S. PAT. OFF.

May ★ One of a Series of Interest to the Petroleum Industry ★ 1952

Du Pont Purchases Plant Site in Texas

A 562-acre tract in the Beaumont, Texas area was recently purchased by the Organic Chemicals Department of the Du Pont Company. The Petroleum Chemicals Division, supplier of tetraethyl lead, is part of this department.

The plant site is bounded by the Neches River and the Kansas City Southern Railroad. Definite plans for plant construction on the new site have not yet been announced. The land, however, was purchased for the purpose of expanding the Company's regular manufacturing activities.

The location is conveniently close to an ample supply of petrochemicals . . . used in making many Du Pont products. There are now three major Du Pont Company plants in Texas, at Sabine, Victoria and Houston.

NEW DU PONT MARKETING AID...

Unique Mileage Calculator Now Available for Your Special Gasoline Promotions

Why does a motorist select *your* gasoline brand . . . or your competitor's?

Miles per gallon is, no doubt, one of his most important considerations—because he can *see* how it affects his pocketbook. That's why many car owners are interested in keeping score on gasoline mileage.

By giving the motorist an interesting gadget that helps him determine his mileage accurately, you can gain his friendship . . . and often create a favorable impression for your brand.

The new Du Pont gasoline mileage calculator is designed to help you do just that. It is essentially a circular slide rule with simple settings that tally miles-per-gallon performance.

The calculator accurately figures the mileage on fuel measured to the nearest fifth of a gallon. And a handy indicator, which the motorist sets with each tank filling, automatically keeps track of his previous mileage. But the tank has to be completely filled at each gas stop to enable the motorist to maintain a continuing check . . . which is, of course, to your advantage.

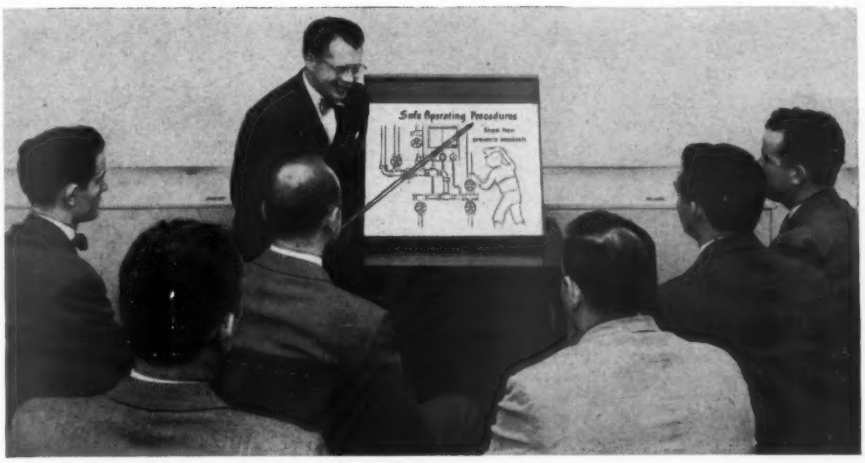
Complete instructions, plus *your* trade-mark and brand name are printed on the front of the calculator. It carries no other advertising. This makes it an ideal tie-in for your special promotions —such as the introduction of a new or improved gasoline, the opening of a new station, or as a low-cost write-in item for testing your advertising or radio program.

The Du Pont calculator design is available to oil companies who, in turn, would have them made with their own brand name and trade-mark in any desired quantity.

New Visual Training Aid On Blending Plant Safety Developed by Du Pont

"Safety" is always a password to the successful handling of tetraethyl lead. And uniform handling procedures are of prime importance in maintaining safety in the blending area.

Since tetraethyl lead was first used in gasoline in the early twenties when Du Pont developed a safe commercial method for making it, a variety of methods for training blending personnel have evolved.



THIS NEW DU PONT TEL SAFETY PRESENTATION can be clearly seen by a group of 20. And it is specially designed for convenient handling by the training instructor or discussion leader.

Now, to fill the need for a single, easy-to-understand tool for training prospective blending plant operators, and as a refresher course for experienced personnel, a carefully detailed turnover presentation has been developed by Du Pont. And this new visual training aid may well become the standard for training blending plant operators throughout the country.

CLEAR, SIMPLE

Stressing "correct operating procedures" as a means to safety, the presentation convinces viewers that correct operation, while not difficult, *is vitally important.* And the presentation is fortified with plenty of "reason why" to make its message penetrating.

For clarity and human interest, the turnover is made up of a series of easy-to-understand illustrations and diagrams. The simple, straightforward text on the back of the turnover is readily visible to the instructor, either for reading verbatim or as a guide for

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED

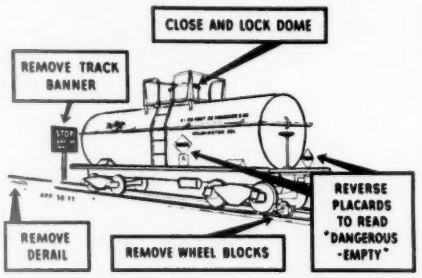
Safety Turnover

delivering the presentation with his own personal showmanship.

Big enough for visual impact, yet small enough for convenient handling, the 47 pages are 18½" by 24". Color has been added to many of the illustrations to show graphically and vividly the actual flow of liquids during the unloading and blending operations.

STEP BY STEP

The presentation is divided into two sections—tank car unloading and blending plant operation. Health precautions and the use of proper procedures are analyzed step by step.



A TYPICAL PAGE shows graphically the important steps in preparing a TEL tank car for release.

In addition to the actual turnover, protected by an attractive "Fabrikoid" binder, an "Instruction Manual" has been prepared to assist the speaker in the initial stages of becoming familiar with his presentation. The handy 8½" by 11" size of the manual permits the speaker to study his material at his desk, at home, on a plane or train without the necessity of handling the larger turnover.

NEVER.... touch anything contaminated with TEL compound without rubber gloves.
ALWAYS....bathe thoroughly after working with TEL....

HUMOROUS FIGURES add interest to a serious point.

Suitable for either the novice or experienced blending crews, the new Du Pont turnover follows the style of the National Safety Council's "Safetygraph."

Coordinator of Du Pont District Laboratories

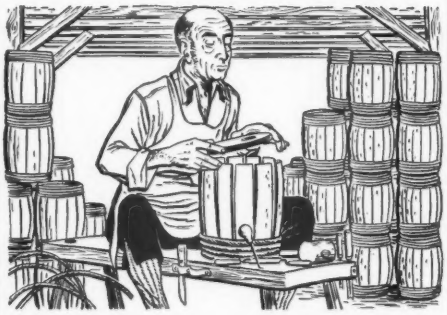
THE PROMOTION of ARTHUR F. BOWE to the position of Laboratory Coordinator was recently announced by the Du Pont Petroleum Chemicals Division.

Since 1949, Bowe has been manager of the Division's Eastern District Laboratory at Wilmington. This laboratory serves refineries on the Atlantic seaboard of the United States. He had previously been acting manager of the Gulf Coast District Laboratory at Houston, Texas, and supervisor of the analytical section of the Du Pont Petroleum Laboratory.

Before joining Du Pont in 1947, Bowe was with the Cities Service Oil Company at East Braintree, Mass. He was graduated, with a B.S. in chemistry, from Tufts College in 1939 and during his senior year was a teaching assistant in chemistry.

ARTHUR F. BOWE

Du Pont Historical Highlights



An early supplier of Du Pont was a Philadelphia firm that sold kegs to the powder mills. The containers were all sizes and qualities, causing confusion in sales and frequent losses from breakage and dampening of the powder. Later, Alfred Victor du Pont, son of the founder, built his own cooperage shop, designed a satisfactory standard keg and, thereafter, made the containers on the mill premises.

Today, containers, ranging all the way from paper envelopes to the tank cars carrying Du Pont's TEL, rank among the most important products Du Pont purchases. And Du Pont buys from more than 30,000 firms. Petroleum companies, suppliers of the petrochemicals used in making Du Pont products, rank well up among the firms supplying the largest volume of commodities bought by Du Pont.

MOVIES AND LITERATURE AVAILABLE

Here is a partial listing of the movies, bulletins, reports, booklets and aids available to you through the nearest Du Pont Petroleum Chemicals Division district office:

Safety for the Small Refinery — A 42-page book on how to set up an effective small refinery safety program . . . . . Serial A-2848

Stability of Present-Day Gasolines — A 12-page paper on the value of storage tests — as compared with induction period—for determining stability of modern gasolines . . Serial A-3199

Pipeline on Wheels—A 26-minute, full-color movie on tank truck safety. Suitable for both training and public relations purposes.

Prints of Du Pont films are available to oil companies for training and public relations purposes. They may be borrowed or purchased.

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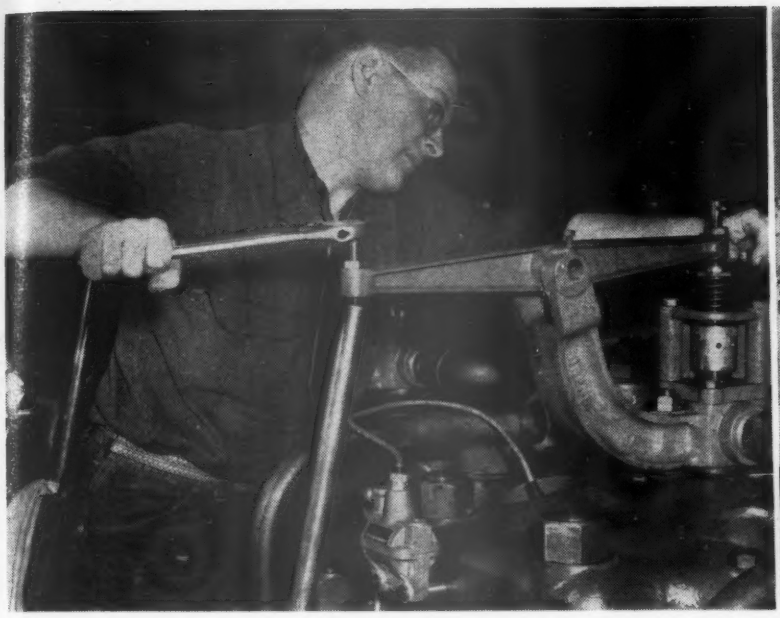
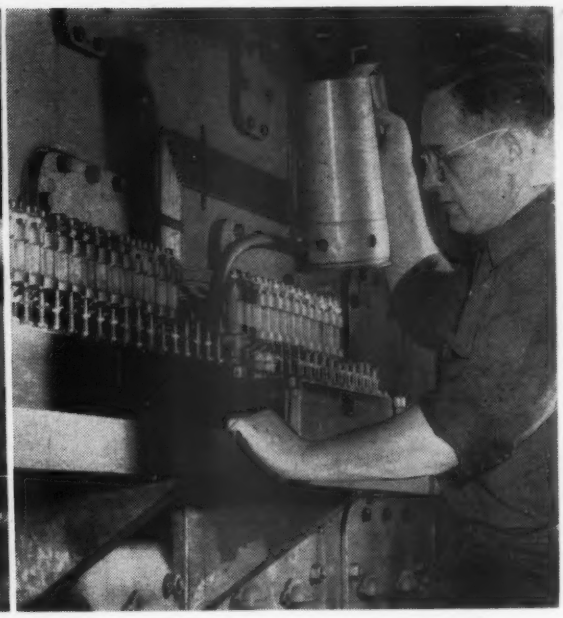


Adjust fuel injection valve tappet clearance.



Fill force feed lubrication, check proper operation, and record oil added.

perfect running order and the frequency and length of shutdowns reduced only through regular care, inspection, and servicing, without overlooking even the smallest part or accessory. Thorough, effective maintenance is only possible when it can be easily controlled, supervised and checked—with a minimum of reference work involved.

The following outlines cover operating and maintenance care of equipment and a schedule of when different types of inspection and service are required. These outlines apply to two-cycle machines, however, by omitting references to injection valves and scavenging equipment and substituting intake and exhaust valves with their valve gear they will, in general, cover four-cycle units.

What Should Be Done and When

Check and Record. The following should be recorded several times each shift on a daily log sheet:

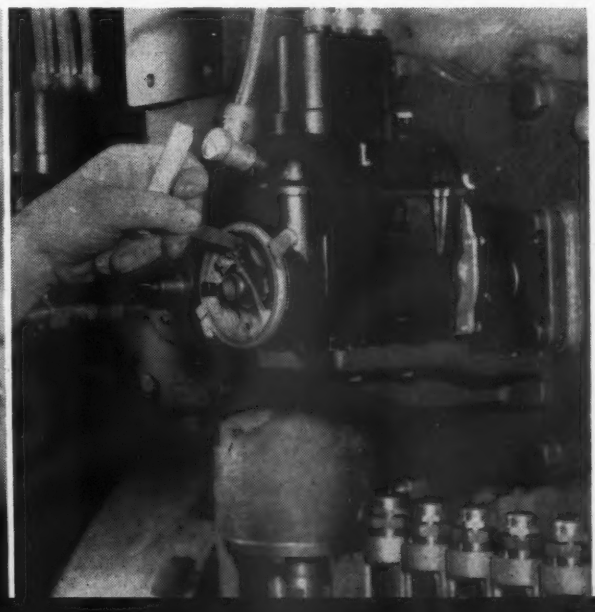
1. The oil pressure in the lubricating system should be kept at the manufacturer's recommended operating pressure.
2. The suction and discharge pressures and temperatures should be checked periodically. The operator should occasionally place his hand on the compressor cylinder valve covers to make certain that the valve temperatures are normal. An increase in temperature usually indicates a leaky valve.
3. The lubricating oil temperatures entering the cooler and engine should be checked periodically.
4. The engine exhaust temperature should check with the manufacturer's recommendation.
5. Check the cooling water temperature and be sure the proper quantity is passing through power cylinders, compressor cylinders, exhaust manifold, oil cooler, and compressor intercooler.
6. The engine speed should be checked periodically.
7. Record voluntary and involuntary shutdowns and remarks covering the cause of the shutdowns.

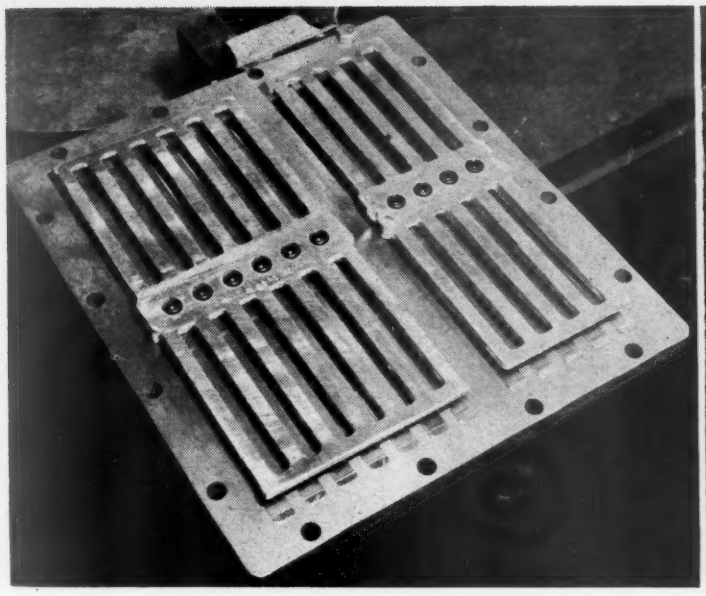
Every Day.

1. Check to see that the fuel scrubber is functioning properly.
2. The crankcase oil should be kept at the recommended operating level. Add oil if necessary and record all the oil used.
3. The force feed lubricators should be filled each shift. Record any oil added to compressor cylinder and power cylinder compartments. See that all force feed pumps are operating properly and keep the sight feed glasses clean at all times.
4. The oil filters should be checked each shift.
5. The fuel injection valve tappet clearances should be checked and adjusted if necessary to maintain an even load on all power cylinders.
6. Lubricate the fuel injection valve stems, packing, and rocker arms.

Clean and check spacing of spark plug gap.
(Note use of wire gage rather than flat feeler gage.)

Magnetos—inspect, clean points, and adjust.





Scavenging cylinder valve.

Power pistons and connecting rods removed from engine, placed in convenient rack for inspection and cleaning.

At One to Two Weeks' Intervals (depending on load and fuel).

1. Clean and check the spacing of the spark plug gaps. This is very important to economic operation.

Every Month.

1. Check to make sure that the overspeed, water temperature, and oil pressure shutdown switches are functioning properly.

2. The magnets should be checked. Inspect breaker gaps and adjust to correct clearance. If points are pitted, clean before making an adjustment.

Every Two to Three Months.

1. Inspect to make sure the air check valves and air starting valves are operating properly — grind or reface if needed.

2. Inspect the scavenging cylinder valves, especially the discharge valves, for possible strip breakage.

Every Three to Four Months.

1. Inspect the fuel injection valves and seats. Grind the valves, if necessary, to avoid the possibility of burned gases being forced back into the gas line. Maintenance and adjustment of the fuel injectors are necessary to keep the load balanced on all cylinders.

Every Six Months.

1. The magnetos should be changed. The replaced magnetos should be cleaned and tested by a competent authorized service station having the proper testing equipment and tools for this work.

Every Year.

The following maintenance will correspond to a general overhaul.

1. Pull the power pistons, remove the rings, and clean the carbon out of the ring grooves. Usually it is not necessary to replace more than one or two of the top rings. The above will hold for normal operation with good fuel and proper cooling; however, if the fuel gas is not clean or the cooling system is inadequate, it is sometimes necessary to pull the pistons every six months, or oftener, to clean carbon and/or replace the firing rings. While the pistons are out, clean the carbon from the intake ports, exhaust ports, and lube oil openings in the cylinder.

2. Inspect the crank pin bearings, crosshead and piston pin bushings, and crosshead slipper bearings.

3. Clean the oil filter elements and case.

4. Drain and wash out the crankcase and oil cooler, clean the pump suction strainer, and refill with new or filtered oil.

5. Inspect the lubricator check valves for proper operation and replace all corroded parts.

6. Clean and inspect the governor and make repairs if needed.

7. Check the timing chain tension and adjust, if necessary.

8. Check the cylinder water jackets for excessive scale formation. Keep the jackets clean so that proper cooling of cylinders is not impaired.

9. Clean both the water and oil sides of the oil cooler tubes.

10. Check for tightness of all the stud nuts securing the upper and lower crankcases together. Tighten any that have become loose.

11. Take micrometer measurements and record all cylinder and piston wear. This is an important gage on the effectiveness of the maintenance program.

Every Three Years.

1. Inspect and keep the proper clearances on main bearings.

2. Check the alignment of the crankshaft. Use a strain gage between the webs of the crank throws.

Other Periodical Check-Ups.

1. The frequency of compressor cylinder inspection depends on the type of service. Keeping the valves and piston rings in good shape is highly important. Reface the valve seats, when necessary, making sure that the proper lift is maintained. Replace cracked or broken discs and springs.

2. Be sure to keep the foundation bolts tight.

3. Check and make sure the fuel gas regulators are maintaining the correct pressure.

4. Check the accuracy of all gages.

5. Clean the air intake filter, when necessary. Excessive pressure drop across the filter is evidence that cleaning is required.

6. Remove any condensate from the starting air supply system.

7. Test the cooling water, when treated, for excessive concentration of treating chemicals. Also check the engine jacket water and add inhibitor as needed to prevent corrosion.

According to Pressure Handled.

1. Under normal conditions, the compressor piston rod and oil wiper packing should be removed, cleaned, and refitted as follows:

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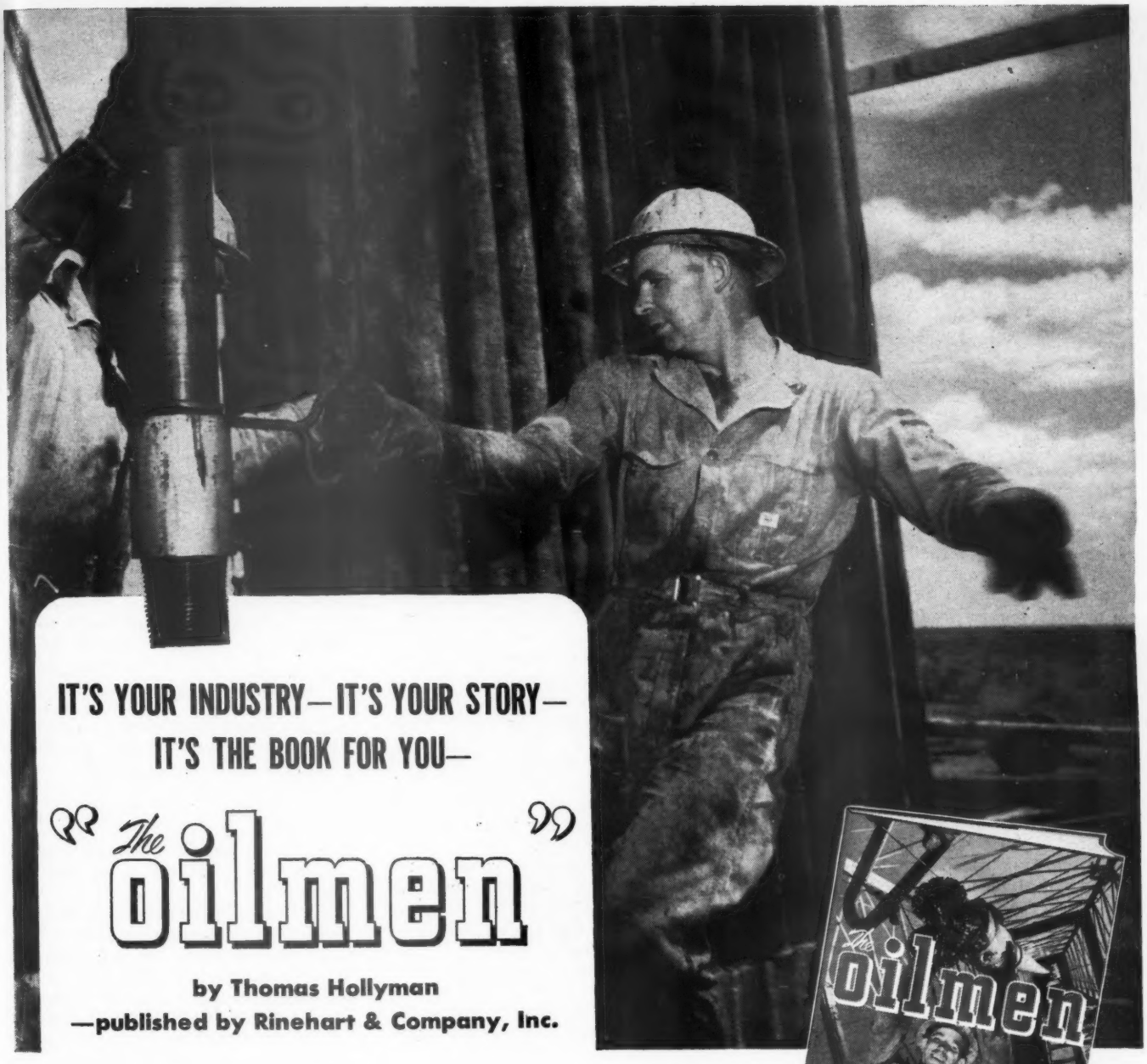

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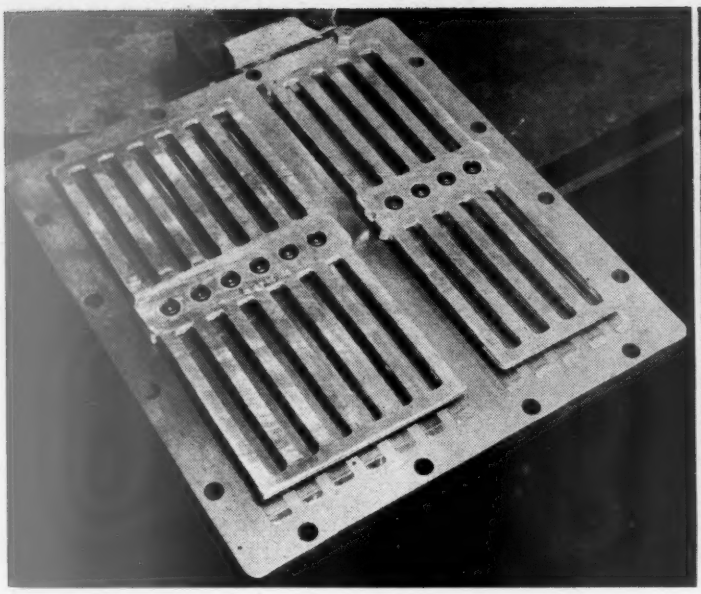

Scavenging cylinder valve.

Power pistons and connecting rods removed from engine, placed in convenient rack for inspection and cleaning.

At One to Two Weeks' Intervals (depending on load and fuel).

1. Clean and check the spacing of the spark plug gaps. This is very important to economic operation.

Every Month.

1. Check to make sure that the overspeed, water temperature, and oil pressure shutdown switches are functioning properly.

2. The magnets should be checked. Inspect breaker gaps and adjust to correct clearance. If points are pitted, clean before making an adjustment.

Every Two to Three Months.

1. Inspect to make sure the air check valves and air starting valves are operating properly — grind or reface if needed.

2. Inspect the scavenging cylinder valves, especially the discharge valves, for possible strip breakage.

Every Three to Four Months.

1. Inspect the fuel injection valves and seats. Grind the valves, if necessary, to avoid the possibility of burned gases being forced back into the gas line. Maintenance and adjustment of the fuel injectors are necessary to keep the load balanced on all cylinders.

Every Six Months.

1. The magnetos should be changed. The replaced magnetos should be cleaned and tested by a competent authorized service station having the proper testing equipment and tools for this work.

Every Year.

The following maintenance will correspond to a general overhaul.

1. Pull the power pistons, remove the rings, and clean the carbon out of the ring grooves. Usually it is not necessary to replace more than one or two of the top rings. The above will hold for normal operation with good fuel and proper cooling; however, if the fuel gas is not clean or the cooling system is inadequate, it is sometimes necessary to pull the pistons every six months, or oftener, to clean carbon and/or replace the firing rings. While the pistons are out, clean the carbon from the intake ports, exhaust ports, and lube oil openings in the cylinder.

2. Inspect the crank pin bearings, crosshead and piston pin bushings, and crosshead slipper bearings.

3. Clean the oil filter elements and case.

4. Drain and wash out the crankcase and oil cooler, clean the pump suction strainer, and refill with new or filtered oil.

5. Inspect the lubricator check valves for proper operation and replace all corroded parts.

6. Clean and inspect the governor and make repairs if needed.

7. Check the timing chain tension and adjust, if necessary.

8. Check the cylinder water jackets for excessive scale formation. Keep the jackets clean so that proper cooling of cylinders is not impaired.

9. Clean both the water and oil sides of the oil cooler tubes.

10. Check for tightness of all the stud nuts securing the upper and lower crankcases together. Tighten any that have become loose.

11. Take micrometer measurements and record all cylinder and piston wear. This is an important gage on the effectiveness of the maintenance program.

Every Three Years.

1. Inspect and keep the proper clearances on main bearings.

2. Check the alignment of the crankshaft. Use a strain gage between the webs of the crank throws.

Other Periodical Check-Ups.

1. The frequency of compressor cylinder inspection depends on the type of service. Keeping the valves and piston rings in good shape is highly important. Reface the valve seats, when necessary, making sure that the proper lift is maintained. Replace cracked or broken discs and springs.

2. Be sure to keep the foundation bolts tight.

3. Check and make sure the fuel gas regulators are maintaining the correct pressure.

4. Check the accuracy of all gages.

5. Clean the air intake filter, when necessary. Excessive pressure drop across the filter is evidence that cleaning is required.

6. Remove any condensate from the starting air supply system.

7. Test the cooling water, when treated, for excessive concentration of treating chemicals. Also check the engine jacket water and add inhibitor as needed to prevent corrosion.

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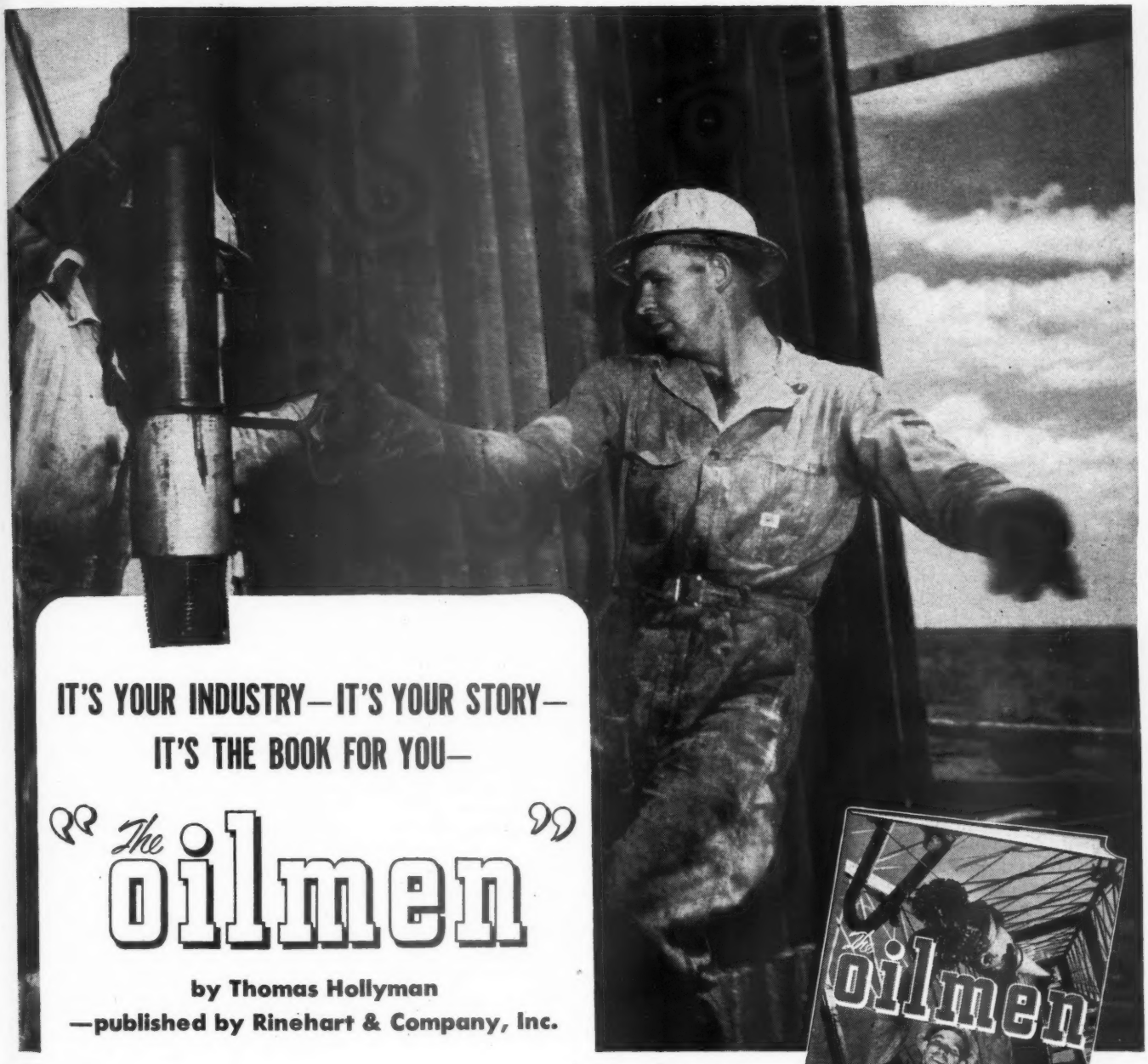

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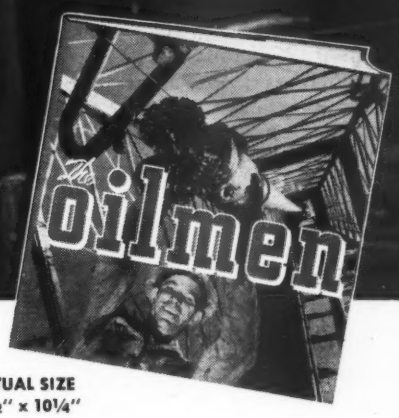

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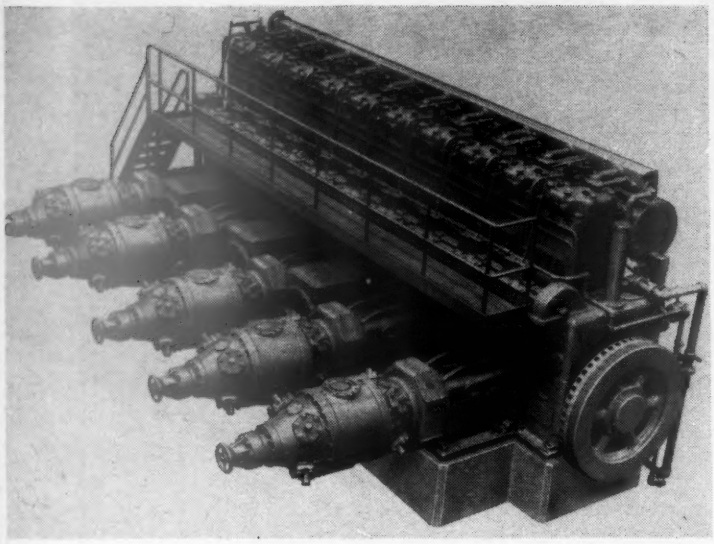


A Clark 2500 bhp vertical gas engine driven compressor.

Take micrometer measurements and record all cylinder and piston wear.

consumption to the power cylinders should be 3000 to 3500 hp hours per gallon. The power cylinders of some types of engines with crankcase oil carry-over require less oil through the lubricator.

3. Lubricating oil for the crankcase and power cylinders should meet the engine manufacturer's general specifications. The formation of sludge is practically non-existent in the crankcase of a two-cycle engine. This gives considerable latitude in the selection of oil. The compressor compartment of the lubricator is usually filled with the same oil used in the power cylinder compartment and crankcase; however, there are many exceptions to this, due to the wide range of conditions encountered when compressing various gases over a wide range of pressures and temperatures. Recommendations to suit your individual compressor requirements can be supplied by your oil supply agent or the engine manufacturer.

4. Stop all oil leaks as quickly as possible for the leaking oil may run down the foundation, seep under the grouting, and destroy the grouting job. It also may rob a vital part of proper lubrication.

5. Keep plenty of warm water circulating through the engine at all times.

6. Break in new compressor rod packing operating on high pressures gradually.

7. Never permit the oil level in the engine crankcase to become too low. Should the lubricator reservoir be allowed to run dry, it may be necessary to prime each pump again.

8. Be sure the load is evenly distributed on all the power cylinders at all times. This can only be accomplished by keeping both the fuel gas and air distribution properly balanced.

9. Keep the scavenging air filter clean at all times. Low scavenging air pressure indicates the air filter is dirty or the scavenging cylinder valves are broken. High pressure indicates the power cylinder inlet ports are carboned up.

10. Keep the compressor cylinder piping clean at all times. Dirt may cause excessive wear of pistons, rings, and cylinder walls, break valve discs, and pit valve seats.

11. Do not put a heavy load on a cold engine; otherwise stuck pistons, cracked cylinders or cylinder heads may result.

12. Never turn water on a hot engine. If the cooling water was not turned on when starting up, shut the engine down and let it cool off.

13. Never attempt to start the engine without unloading the compressor cylinders.

14. Check the temperatures and pressures after the engine has been started.

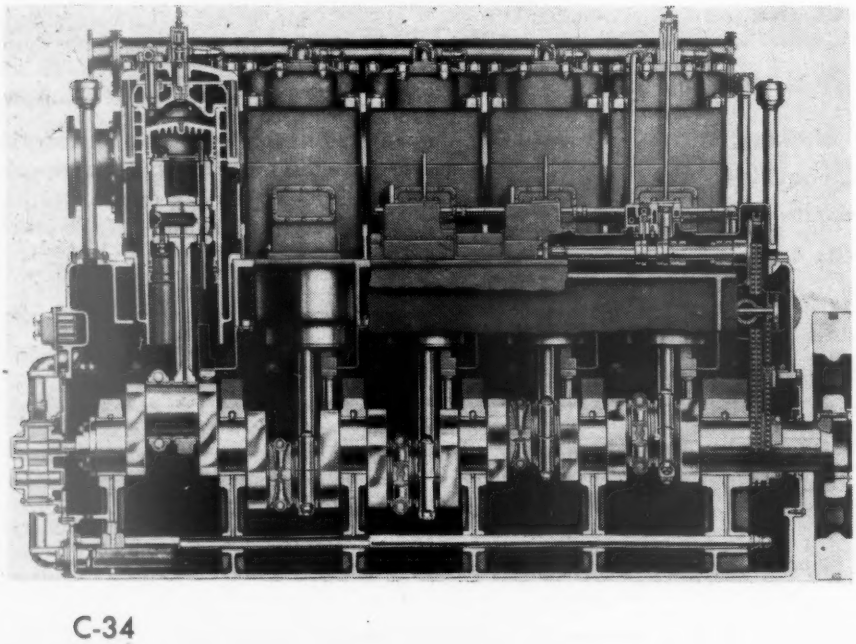
15. Do not permit an engine to continue to run if no reading is shown on the oil pressure gage, or if the pointer on the gage surges back and forth. Shut the engine down and investigate the trouble.

16. If at all possible, do not use fuel gas containing hydrogen sulfide.

The above suggested operating practices and recommended inspection and repair schedule are a sound basis for all maintenance programs whether for single field units or large multi-unit installations. They are basic with secondary modifications for convenience in exercising close control from records and for co-ordinating schedules with operations which involve seasonal load factors, allowable field production rates, and periodic shutdowns for general plant maintenance.

Many of the improvements and design features that have developed the vertical gas engine driven compressors to their present degree of efficiency and dependability resulted from suggestions originated by compressor plant operating and maintenance personnel. In most cases the sources of information that encouraged such ideas and suggestions were revealed through and confirmed by accurate records of well organized operating and maintenance programs. * * *

Longitudinal section of a Clark vertical gas engine driven compressor. (Note crank shaft and main bearings.)



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Steam Injection in Cracking Coils

Q ***Question from P. L. Smith, Magnolia Petroleum Company to R. R. Gumaer, technical assistant to vice president, Pan-Am Southern Corporation.***

The article, "Coker Solves Heavy Fuel Problems", (*The Petroleum Engineer*, April, 1951) concerning your delayed coker operation creates special interest in your use of steam in the furnace coil. Although no statement was made concerning the reason for steam injection, it is assumed that it is used to prevent coil coking, thereby extending unit runs.

Application of steam injection for this purpose has been considered for our delayed coker coil at Fort Worth, but no information concerning its value has been found. Would you please send us any information concerning its effectiveness, amount required, etc., that you can?

Have you ever encountered the use of water injection in a furnace inlet such as this? If so, what were the results?

A The following information is supplied with regard to steam injection in our delayed coking unit furnace.

The furnace is a Lummus type bottom fired furnace with two parallel coils consisting of upper roof tubes, lower roof tubes, and side wall tubes in the radiant section of the furnace for oil heating. Steam injection points are provided at the inlet of the coils, inlet to the lower roof tubes and outlet of the lower roof tubes. We have used steam injection to the inlet of the lower roof tubes of each coil since the unit went on stream in September of 1950. During the early operation of the unit, however, steam injection was also used at the outlet of the lower roof tubes. Table 2 of Arch L. Foster's article, "Coker Solves Heavy Fuel Problems," (*The Petroleum Engineer*, April, 1951) gives typical operating conditions during this early period including steam injection to the furnace. As a result of operational experience gained on the unit, the steam injection to the outlet of the lower roof tubes has been discontinued and the steam injection to the inlet of the lower roof tubes has been reduced to an estimated 80-160 lb per hour with the steam injection being greater at lower feed rates.

Run lengths of 12 to 13 weeks have been made since the unit went on stream. The maximum coke deposit in the furnace tubes at the end of the first 12 week run was 3/16 to ¼ in. On all shutdown since the first, however, the furnace tubes have been steam-air decoked and the actual coke deposit in the tubes has not been observed. The coke deposits in the transfer line and the time required for steam-air decoking indicate very little coke in the furnace tubes. In the past, the coking unit has been shut down at the same time as our combination crude and thermal cracking unit and the maximum run length possible on the coking unit has not been determined.

We have not had any experience with water injection to the furnace oil streams at our coking unit. We did encounter erratic firing of the coking furnace caused by entrained water in the 275 psig injection steam until a separator was installed in the injection steam line.

The steam rate to each injection point is controlled with a ¾-in. Hancock 600 lb Globe Flocontrol valve (Catalog No. 534AV-2V). We are running at the present time with the control valves to the inlets of the lower roof tubes from 0.3 to 0.5 rounds open which we estimate to be from 80 to 160 lb per hour.

To summarize, we do feel that steam injection does reduce coking in the furnace by increasing the oil velocity in the section of the furnace where the oil is subjected to cracking temperatures, that is, the lower roof tubes and side wall tubes. We have reduced the steam injection rate to a point considerably below the initial rate used but do not plan any further reduction.

Butadiene Recovery

Q **I understand that several methods are employed for the concentration of butadiene from reaction mixtures, such as additive agents, extractive solvents, etc. Will you discuss two or three of the best methods from the viewpoint of optimum operating conditions, materials employed, and comparative efficiencies, advantages, and disadvantages.**

A Four butadiene purification methods are practiced industrially. These are the extractive distillations with furfural and with dichlorethyl ether (chlorex), azeotropic distillation with ammonia, and extraction with ammoniacal copper acetate liquor. The two used on the largest scale with petroleum butadiene are the furfural and copper liquor processes as employed in the government synthetic rubber program. The chlorex and ammonia azeotrope processes have also been used in much smaller private petroleum butadiene operations. The chlorex process was also used in the government program for purification of alcohol butadiene but this was probably an easier operation than petroleum butadiene purification. The difficulty of this operation is indicated by the close range of the boiling points of the C_4 hydrocarbons coupled with the high butadiene purity and low trace impurities required by the rubber reserve butadiene specification given below.

Boiling points of C_4 hydrocarbons in crude butadiene from petroleums.

Hydrocarbon	Normal boiling point
Isobutane	10.9F
Isobutene	19.6
Butene-1	20.7
Butadiene-1,3	24.1
Normal Butane	31.1
Trans Butene-2	33.6
Cis Butene-2	38.6
Vinyl acetylene	42.0
Ethyl acetylene	47.7
Butadiene-1,2	50.5

Rubber reserve specifications* butadiene, polymerization grade.

	By weight
Conjugated diene content	98.0% min.
Peroxides, as H_2O_2	10 ppm. max.
Acetylenes, as vinyl acetylene	0.1% max.
Butadiene dimer	0.2% max.
Non-volatile residue	0.1% max.

* Excerpts from specification LM2.1.0.1.

In addition normal butane and butadiene form an azeotrope containing approximately 5 per cent normal butane. This precludes making specification butadiene by conventional fractionation and hence the methods of petroleum butadiene purification all depend on altering the normal relative volatilities of the C_4 hydrocarbons in the crude butadiene. Using these methods the paraffins are the most volatile, the olefins next, and the dienes the least.

The ammonia azeotrope method is unusual in that though the hydrocarbon-ammonia azeotropes have the same boiling points, in admixture they possess significantly different relative volatilities which permit their separation by distillation with a negligible temperature gradient in the tower where the ammonia is present in sufficient concentra-

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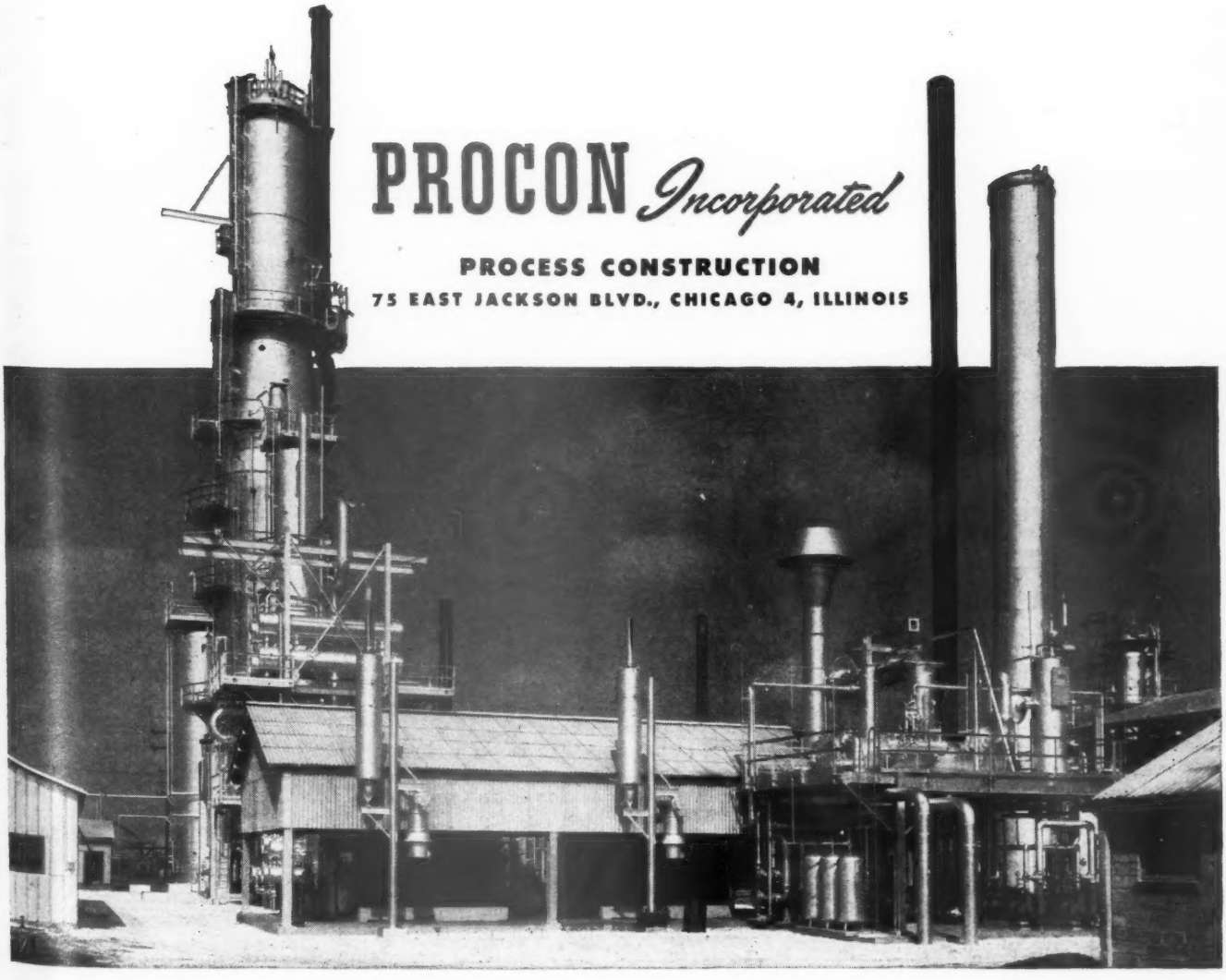

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tion to form the hydrocarbon azeotropes.

Boiling points vs. relative volatility at 215 psig.

Ammonia Azeotrope with	Boiling point	Approximate relative volatility
Normal Butane	102F	1.6
Butenes	102	1.3
Butadiene-1,3	102	1.0

A summary of some of the major operating features of the three purification processes is given below.

Comparison of petroleum butadiene purification processes.

Process	NH_3 Azeotrope Distillation	Furfural Extractive Distillation	NH_3-Copper Liquor Extraction
Butadiene in feed	From 50%	From 40%	From 40%
Butadiene recovery	96%	above 95%	above 96%
Butadiene product purity	99%	99.5%	98.5%
Government program Installed capacity short tons per year	None	205,000	206,000
Process conditions			
Maximum pressure, psig	275	100	15-30 est.
Maximum temperature, F	250	340	225
Minimum temperature, F	—40	70	zero
Material of construction	Some 3% Ni steel, rest mild steel	mild steel	mild steel

The results obtained using these processes do not differ in any major way. For very large scale purification, however, the ammonia azeotrope process may be at some disadvantage as to plant investment because of the operating pressure of the azeotrope tower and because of the need for special alloy steel for the refrigeration units operating at very low temperature. The ammonia make-up required is probably not excessive.

The copper liquor process is the most widely used and has given good satisfaction.

The furfural process is also highly developed and widely used. The furfural loss due to polymerization in process is down to around 0.007 per cent per pass. This process produces somewhat higher purity butadiene than the other two and might well be the one preferred by a refinery organization without previous chemical experience. Before a choice is made, however, it would be only prudent to make a direct engineering comparison of the purification methods under consideration giving particular attention to the heat and cooling water requirements. *J. H. Boyd.*

Lubricating Effects of Greases

Q What is the source of the lubricating properties of a grease—the oil base, or the soap base, or both? If soaps have any lubricating effect, what variations in these properties are possessed by different soaps?—M. E. E.

A The general opinion is that the oil or fluid in a lubricating grease is responsible for the lubricating properties of such products. A group[2], who have done considerable work upon the structure of lubricating greases, found no evidence that the soap has value as a lubricant. As their work was with a specific soap, namely, the sodium soap made largely from 12-hydroxystearic acid, this conclusion may not be valid for all soaps with varying metal and fatty acid radicals.

On the other hand, there is considerable evidence[3] that soaps alone are lubricants. Much of this evidence, however, has been obtained when working with dry soaps. Soaps prepared *in situ* were found by Bowden *et al* to have valuable wear preventive action. In fact, the value of fatty acids in reducing friction is largely due to the formation of soaps on the metal surfaces.

In order to demonstrate the relative value of an oil and the lubricating grease prepared from the same, tests were made employing an Almen E. P. Test Machine[3]. First, an oil of 300 SUS at 100 F and one of 500 SUS at 100 F were tried. In each case immediate seizure occurred at a load of 4000 psi. After the 300 oil was compounded into a No. 2 NLGI grade of calcium base lubricating grease and tested on the Almen machine, failure occurred after a load of 5000 psi had been maintained for several minutes. Similarly, a barium base lubricating grease was made, using the 500 oil and testing on the Almen machine. Seizure occurred after several minutes at a load of 5000 psi. These tests seem to indicate that the soap added to the lubricating value of the composition.

In a report on roller bearing lubrication[1], it was found that lubricating grease allowed a smaller temperature rise over ambient than did oil. An oil of 150 SUS at 100 F showed a rise of 92 F, while a lubricating grease containing an oil of 105 SUS at 100 F showed a rise of 25 F and a lubricating grease with an oil of 300 SUS at 100 F gave a rise of 45 F over ambient.

From a theoretical standpoint the soap should have more influence in preventing metal to metal contact than the oil. As most mineral oils do have polar characteristics, they do not attach themselves to the metal in the same way that soaps do. In the case of soaps the polar end should become attached to the metal and the long chains of the non-polar end project into the oil layer. If such a condition exists, this would give an orderly arrangement so that less work would be required to move one film over the other than if the arrangement were random. As noted before, such facts have been demonstrated for soaps alone but there still remains some question whether the same arrangement exists in soap-oil systems.—C. J. B.-R. R. M.

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2. Bondi, A, *et al*, Proc. Third World Petroleum Congress, Sec. 7, 373-95 (1951).
3. Boner, C. J., Institute Spokesman, 12, No. 11 (1949).
4. Bowden, F. P., Gregory, J. N., and Tabor, D., Nature, 156, 97-101 (1945).

Grease "Filler" Materials

Q Are any synthetic "filler" materials, such as methocel, ethocel, or other plastic, etc., types of materials employed to any advantage in greases? If so, in what types of greases, and what properties are added by these materials?—M. E. E.

A There does not seem to be a record of the use of either methyl cellulose or ethyl cellulose in formulating lubricating greases.

Perhaps one of the reasons why these products are not used is the solubility characteristics. Methyl cellulose, of course, is soluble in water and hence would not serve for all lubricating purposes. Since ethyl cellulose is only soluble in alcohols and in solvents containing a large proportion of aromatics, it is probably not soluble in mineral oil.

To produce a satisfactory lubricating grease, the bodying agent, while it may be soluble in oil at high temperatures, should crystallize from the liquid upon cooling. The crystallites so formed should be of such a nature that they will agglomerate into aggregates of greater length than breadth, generally taking the form of fibers. These fibers then hold the oil by capillary attraction. If either the methyl or ethyl cellulose could be deposited from an oil solution, it is questionable if these materials would crystallize as a network of fibrels, but would likely deposit as a continuous structure rather than as a network.

If methyl or ethyl cellulose were considered as modifiers for soaps in the manner in which water, glycols, higher alcohols, and fatty acids act, they should aid in the wetting of the soap fibers by the oil, or facilitate the soap crystallization. Either action seems unlikely with the proposed compounds.

Certain materials of somewhat the nature suggested as far as crystallization and solubility are concerned, are claimed[1] as reinforcing agents in alkali or alkaline earth soap lubricating greases. In one case the compound used was water-dispersible polyvinyl alcohol. A water-dispersible protein or high molecular weight amino acid derived therefrom, such as casein, gelatin, arginine, asparagine, or the albumins may also be employed. Another claim is for the resins representating the initial condensation products between phenol and formaldehyde. Finally, the natural gums such as gum arabic, gum tragacanth or karaya gum were used.

—C. J. B.-R. R. M.

Reference

1. T. G. Roehner and Geo. W. Murrey, U. S. Patents 2,487,376-377-378-379. Nov. 8, 1949.

A bank of 24 Beaird pressure storage tanks in a North Louisiana gasoline plant.

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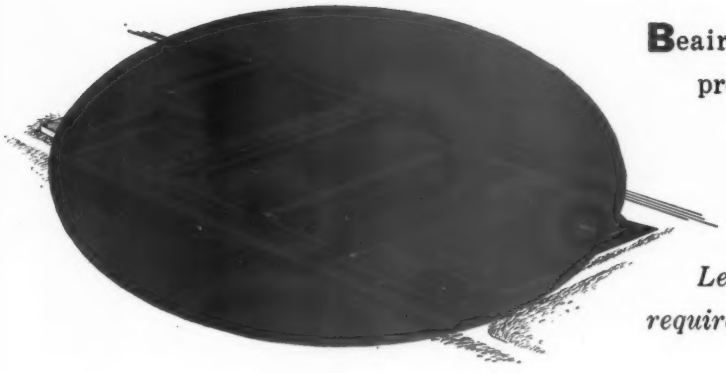

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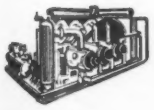

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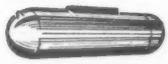

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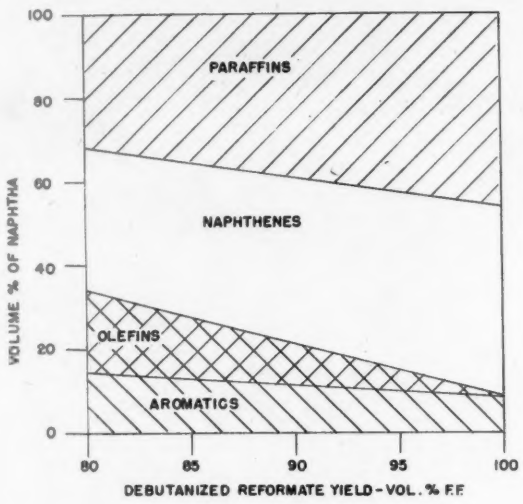

FIG. 1. Composition of thermal reformate East Texas naphtha.

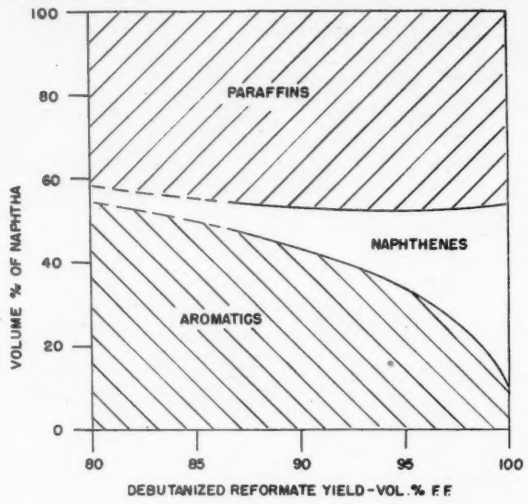

FIG. 2. Composition of catalytic reformate East Texas naphtha.

It's the Catalyst That Counts†

Selectivity, stability, stamina—these are the tripod that supports a good catalyst for the reforming process

M. J. FOWLE*, R. D. BENT*, B. E. MILNER*, G. P. MASOLOGITES*

INCREASED octane requirements of today's motor cars have presented every refiner, large and small, with the immediate challenge of providing fuels for the present and future automobiles. The refining industry has made considerable progress in keeping pace with the increasing octane demand since the end of World War II by the installation of a large volume of catalytic cracking capacity. There is a definite limitation, however, in the ability of catalytic cracking to raise the octane level of the whole refinery gasoline pool. The principal reason for this is the high percentage of straight run and natural gasolines of relatively low octane that must be blended into motor fuels. Thermal reforming of these materials has been practiced for express purpose of upgrading octanes. It is well recognized, however, that by virtue of the uncontrolled reactions taking place in thermal reforming, this method of octane improvement is both costly and limited in potential octane ceiling. The change in chemical composition of a thermally reformed naphtha with increasing reforming severity is illustrated in Fig. 1. It will be seen that, in this case, octane improvement is realized primarily by the cracking of paraffins to olefins with a relatively minor change in the aromatic and naphthene content.

With this as a background, a number of catalytic reforming processes[1,2] have been developed over the past few years to satisfy the demand for higher octanes from straight run and natural gasoline sources. Catalytic reforming accomplishes this economically by controlling the chemical reactions that take place. As contrasted to thermal reforming, the Atlantic catalytic reforming process accomplishes octane improvement by the isomerization of paraffins and naphthenes and the conversion of naphthenes to aromatics as shown in Fig 2. Olefins are not produced. Of prime importance is the fact that these reactions result in a high liquid recovery of finished reformate. The most important and distinguishing feature of any catalytic reforming process is the catalyst itself; for this, to a major extent, influences the daily operating economics of the process and the complexity of the processing equipment required to carry it out.

What are the important characteristics of a reforming catalyst? One is selectivity—the ability of the catalyst to promote the desired reactions of dehydrogenation and isomerization while controlling cracking. A second property is stability—will the catalyst maintain the desired yield-octane relationships over an extended life? Another must feature of a reforming catalyst is stamina—the ability of the catalyst to perform satisfactorily under the many varied conditions encouraged in normal refinery operations.

†Presented at the Fortieth Annual Meeting of The Western Petroleum Refiners Association, San Antonio, Texas, March 31, April 1-2, 1952.

*Atlantic Refining Company, Philadelphia, Pennsylvania.

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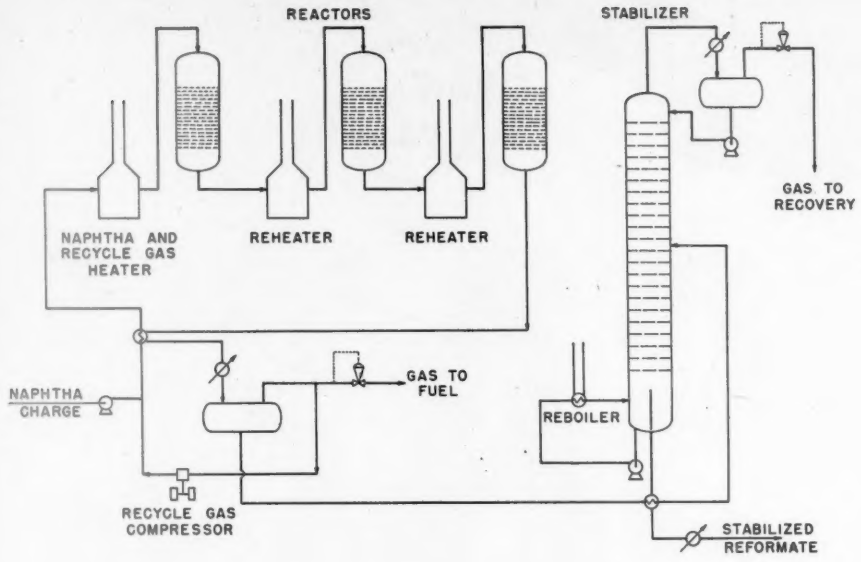

FIG. 3. Simplified flow diagram.

TABLE 1. Atlantic catalytic reforming process. Typical operating conditions, East Texas straight run naphtha

Naphtha feed: boiling range	175—375F
Space velocity: lb/hr Naphtha feed/lb catalyst	3.0
Reactor pressure, psi	500
Reactor inlet temperature	920F
Recycle: Mol recycle gas/mol naphtha charge	10/1
Recycle gas: Mol per cent hydrogen	95%
Temperature drop across reactors: 1st	100F
2nd	50F
3rd	20F

TABLE 2. Atlantic catalytic reforming process, utility requirements.

Basis: East Texas type st. run naphtha	10,000 BPD unit
Reactor furnaces—Delivered duty	57 MM Btu/hr
Stabilizer reboiler—400 lb steam	18,000 lb/hr
Recycle gas compression requirements	1650 BHP
Power requirements: Pumps, fans, etc.	450 KW
Cooling water make-up	175 GPM

Process and Equipment

To illustrate the role of the catalyst in obtaining the desired reforming results with minimum capital and operating expenditures we should like to describe the Atlantic catalytic reforming process. The Atlantic process is a continuous, normally non-regenerative process utilizing multiple fixed bed reactors. A schematic process flow diagram is shown in Fig. 3. The feed naphtha, direct from tankage is joined with a recycle hydrogen stream. The mixture is heated to operating temperature by reactor effluent-feed exchange and a furnace before passing to the reactor section. Two or three reactors are utilized to accomplish the completed reaction at the desired temperature level. As the catalytic reforming reaction is predominantly endothermic, reheaters are employed between reactors to bring the naphtha-hydrogen mixture back to the operating temperature The final reactor effluent, after exchange with feed, is cooled and passes to the gas separator. The recycle hydrogen stream is compressed and returned to the reactor while the net production is sent to fuel or other uses. Gas separator liquid is charged to a conventional fractionating tower for stabilization. Typical operating conditions for reforming an East Texas straight run naphtha are shown in Table 1, and Table 2 lists utility requirements for a 10,000 bbl per day reforming operation.

The simplicity of the process is emphasized by the absence of any feed pre-

TABLE 3. Catalytic reforming of straight run naphthas.

Feed Stock No.	1		2		3	4		5	6	7	8	9
Crude Source	East Texas		East Texas		West Texas	Oficina		Mid-Continent	California	Tucupido	Gulf Coast	Gulf Coast
Charge												
API	56.5		54.6		51.6	51.5		47.9	46.9	50.3	50.2	53.1
RVP	0.8		0.3		0.1	0.5		0	0	0.8	0.2	0
ASTM 0	181		218		228	242		317	284	232	268	196
10	211		236		247	259		324	295	250	282	226
50	255		268		281	279		336	309	274	306	280
90	320		317		346	318		356	338	312	355	350
E.P.	370		365		406	348		401	360	374	396	382
Sulfur—wt per cent	.005		.005		.092	.013		.002	.14	.003	.047	.002
Res. octane 0 cc	54.9		51.5		51.2	56.9		36.0	60.2	60.3	46.5	47.4
3 cc					70.0			63.1	76.1		66.9	73.9
Paraffins, volume per cent	43.2		42.1		40.5	42.6		48.2	27.4	28.5	46.8	49.2
Naphthenes, volume per cent	47.6		46.7		38.7	36.5		36.1	59.6	32.5	36.4	34.0
Aromatics, volume per cent	9.2		11.3		20.8	20.9		15.7	13.0	28.0	16.8	16.8
Yields. Per cent of feed												
C_5 plus, volume per cent	90.9	86.7	84.4	86.7	89.2	91.0	88.9	89.5	88.4	93.1	85.2	87.4
C_4 volume per cent	3.9	7.5	8.2	6.3	7.7	4.8	6.4	5.5	4.1	3.0	11.8	8.6
C_3 volume per cent	2.3	3.7	5.1	3.8	3.0	2.9	3.9	5.4	3.7	2.5	4.7	4.9
C_3 plus, volume per cent	97.1	97.9	97.7	96.8	99.9	98.7	99.2	100.4	96.2	98.6	101.7	100.9
H_2 weight per cent	1.57	1.78	1.90	1.91	1.20	1.18	1.31	1.11	1.57	1.14	1.07	1.34
C_1 weight per cent	.17	.27	.17	.12	.31	.08	.10	.21	.27	.09	.13	.23
C_2 weight per cent	.20	.37	.43	.30	.34	.15	.28	.45	.51	.14	.42	.52
10# RVP naphtha, volume per cent	103.1	96.8	96.2	99.7	102.3	103.7	100.0	102.1	101.5	107.4	96.5	100.6
Excess C_4's, volume per cent	—8.3	—2.6	—3.6	—6.7	—5.4	—7.9	—4.7	—7.1	—7.4	—11.4	0.5	—4.6
Product quality												
C_5 plus—Res. octane 0 cc	80.3	86.2	92.6	89.2	81.0	83.4	88.5	83.0	91.6	84.8	86.2	82.2
3 cc	93.0	97.1	98.9	97.3	92.9	94.4	98.1	94.1	99.6	94.6	96.3	94.4
10# naphtha res. octane 0 cc	82.0	87.2	92.9	89.7	82.8	84.8	89.2	84.5	92.0	86.2	87.2	83.8
3 cc	94.0	97.6	99.1	97.9	94.0	95.8	98.5	95.0	99.8	95.5	96.9	95.2
C_5 plus naphtha												
API	52.2	50.5	47.8	47.8	50.2	48.1	48.2	46.1	43.1	47.2	47.7	49.7
RVP	2.6	3.1	2.3	1.8	1.9	2.3	3.0	2.2	4.0	1.6	2.7	1.7
ASTM 0	162	134	126	132	114	120	112	114	114	137	122	128
10	192	179	187	201	203	221	198	197	237	220	191	184
50	244	240	258	261	265	278	278	322	314	270	282	252
90	319	324	323	329	342	324	332	368	357	313	341	338
E.P.	393	394	380	389	408	394	383	442	421	387	425	418
Sulfur, weight per cent	.001	.001	.001	.001	.002	.001	.001	.001	.001	.001	.001	.001
Hydrogen purity, Mol per cent at 500 psi 95F	95.8	94.7	96.4	98.0	92.2	97.0	95.5	93.0	94.9	96.5	95.5	95.2

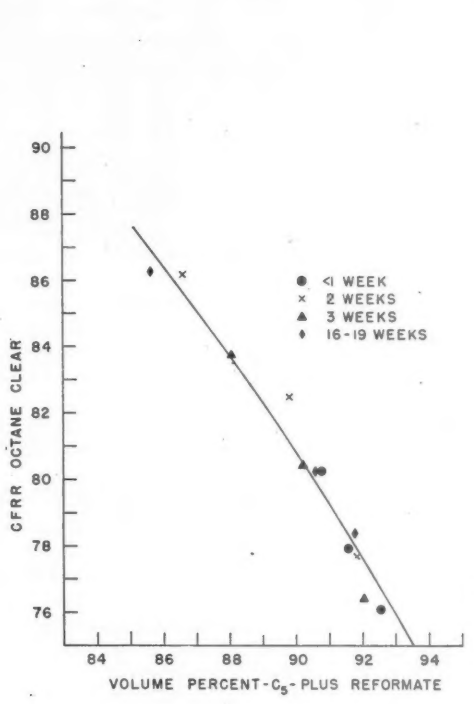

FIG. 4. Effect of catalyst age on yield—octane relationships—E.T. naphtha.

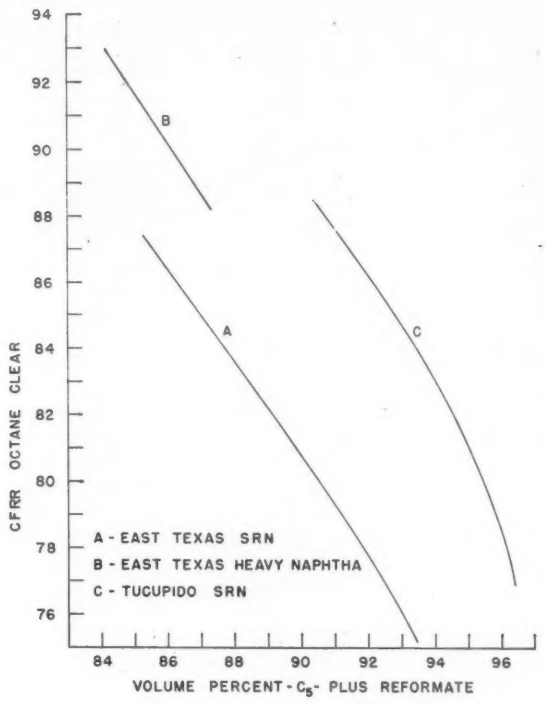

FIG. 5. Effect of charge stock on yield—octane relationship.

paration facilities or costly catalyst regeneration equipment. The importance of Atlantic's catalyst in permitting these process improvements is discussed in more detail below. In addition, the stabilized reformate is of such quality that no naphtha treatment is required before blending the product into finished gasoline. Under normal operating conditions, for motor fuel production, carbon laydown on the catalyst is negligible. If, however, regeneration of the catalyst should be required, this may be accomplished, in place, by passing a dilute air-in-steam mixture over the catalyst. When charging high sulfur stocks, it is desirable and practical to minimize the sulfur content of the reactor feed. In the Atlantic process, this is accomplished by a simple desulfurization of the recycle hydrogen stream (such as in a conventional amine unit).

Because of the simplicity of the equipment required for the process it is equally applicable to large or small units. Units are currently being constructed in sizes ranging from 750 to 12,000 bbl per day charge capacity. Investment costs range from $350 to $450 per barrel of naphtha charge.

Pilot Plant Development

The Atlantic catalytic reforming process is the result of several years of intensive development work in our own laboratories and in those of the Davison Chemical Corporation, one of the nation's leading catalytic manufacturers. A previous paper by Fowle et al[3] has reviewed the development of this reforming catalyst. A six barrel per day continuous pilot plant has been in operation for nearly two years evaluating a wide variety of potential feed stocks and catalyst preparations. The basic flow diagram of this pilot plant is essentially similar to the commercial units currently being designed and constructed.

TABLE 4. Catalytic reforming of natural gasolines.

Charge material	North Texas	South Texas	
Charge			
API	68.1		67.4
RVP	4.7		5.3
ASTM 0	136		114
10	158		140
50	201		194
90	293		282
E.P.	362		351
Sulfur—wt %	.001		.003
Res. octane 0 cc	49.7		64.4
3 cc	—		83.7
Paraffins—vol per cent	77.6		62.4
Naphthenes—vol per cent	14.0		30.3
Aromatics—vol per cent.	8.4		7.3
Yields, per cent of feed			
C_5 plus, vol per cent	87.5	79.0	81.2
C_4 vol per cent	9.3	15.5	11.4
C_3 vol per cent	4.6	9.0	8.3
C_3 plus, vol per cent	101.4	103.5	100.9
H_2 wt per cent	0.50	0.50	1.20
C_1 wt per cent	0.15	0.60	0.34
C_2 wt per cent	0.30	0.89	0.68
10# RVP naphtha, vol per cent	93.7	82.6	83.5
Excess C_4, vol per cent	3.1	11.9	9.1
Product quality			
C_5 plus res Oct. 0 cc	73.9	80.5	88.5
3 cc	90.3	93.7	98.4
10# Naph, Res. Oct. 0 cc	75.2	81.0	83.5
C_5 plus naphtha 3 cc	91.0	93.9	88.6
API	68.4	67.8	62.9
RVP	5.9	7.3	8.3
ASTM 0	115	113	116
10	136	122	125
50	178	160	170
90	264	285	300
E.P.	334	337	360
Sulfur, wt per cent	Nil	Nil	.001

Catalyst Performance

Typical pilot plant results from a variety of feed stocks are shown on Tables 3 and 4. Analysis of these data will show the outstanding characteristics of the Atlantic catalyst in obtaining and maintaining yield-octane relationship. Such results can only be obtained by a selective catalyst which maximizes dehydrogenation of naphthenes and isomerization of paraffins and naphthenes while controlling the undesirable cracking reactions. This is emphasized by the yield and quality data in Table 3. It will be seen that the yields of methane plus ethane are consistently below 1 weight per cent of feed and that the purity of the recycle hydrogen stream runs approximately 95 mol per cent hydrogen. This, incidentally, suggests utility other than fuel for the hydrogen make gas. Further evidence of the selectivity of this process is shown by the high liquid recovery of propane and heavier which for the wide range of feed stocks and reforming severities illustrated runs from 96.8 to 101.7 volume per cent of fresh feed. This is particularly significant in many refinery locations where fuel gas is of little economic or material value.

Although it is of great importance to have a catalyst that produces high yield-

octane values when relatively new, the stability of the catalyst in maintaining these results is a major factor in determining the economics of the process. This important feature was studied in a recent five-month run on a batch of Atlantic catalyst in the pilot plant. A standard, wide cut, East Texas naphtha was charged to the unit at intervals over the length of the run. These test data are shown in Fig. 4, in which it will be seen that there was no change in the yield-octane relationship over the entire period. Data from two of these test periods are listed in Column 1 of Table 3, together with the properties of the feed stock used in this program. Evaluation of this batch of catalyst was discontinued while operation was still entirely satisfactory at a catalyst life of 30 bbl of feed per pound of catalyst.

The danger of generalizing on the yield-octane results from various feed stocks is emphasized by reference to Fig. 5 and Table 3. Curve A is the data previously referred to for a wide cut, from East Texas naphtha. The effect of width of boiling range is shown by comparison of curves A and B where it will be seen that, although the narrow boiling stock (Column 2, Table 3) had a 3.4 lower octane, the debutanized reformate was three points higher at the same yield. Data from Tucupido, an aromatic Venezuelan naphtha, are illustrated in curve C, showing the effect of chemical composition on final yield octane results. (About 83+ O. N. at 94 per cent yield.—Ed.)

It has been stated that under normal operating conditions for motor fuel production carbon deposition on the catalyst is negligible. Under very severe reforming conditions or in the case of a major unit upset, however, carbon may be formed on the catalyst, reducing its activity. With the Atlantic catalyst this condition may be corrected by a simple regeneration operation, in place, using a dilute air-in-steam mixture to burn off the carbon deposit. This is an important feature of the process as it eliminates the need for expensive regeneration facilities in the plant and greatly extends the useful life of the catalyst.

The fact that this catalyst can be regenerated by air and steam brings out another significant characteristic; namely, that water has no harmful effect on the catalyst. This is important both from the standpoint of catalyst regeneration and the fact that it is unnecessary to provide facilities for elimination of water from the feed in normal refinery operations. During the above mentioned five-month run an extended program of water injection into the reactor feed (in concentrations up to 1 weight per cent) was studied. As would be expected from its chemical composition, no deactivation of the catalyst or change in product distribution was found.

It has been shown that essentially all the sulfur in the naphtha feed is converted to hydrogen sulfide upon initial contact with the catalyst and further that the various classes of sulfur compounds behave as hydrogen sulfide toward the catalyst. Sulfur is a temporary poison on the catalyst, using up some of the catalyst surface and reducing activity. The fact that this is a temporary phenomena has been repeatedly demonstrated by the catalyst returning to original activity when the sulfur level of the charge is reduced. At feed sulfur contents of about 0.1 per cent the depression of catalyst activity becomes significant enough to justify corrective action. Because of the large hydrogen recirculation, desulfurization of this recycle stream is a relatively simple method of handling higher sulfur feed stocks. For example, in an operation with no sulfur removal, charging a feed containing 0.10 weight per cent sulfur, 40 lbs per hour of sulfur would be charged over one ton of catalyst at a given space velocity and hydrogen recycle rate. If the sulfur content of the recycle gas were reduced to 10 grains per 100 cu ft the sulfur charged over the catalyst would be 9.5 lbs per ton of catalyst. This would be equivalent to charging a feed stock with 0.025 weight per cent sulfur with no desulfurization facilities. The fact that the Atlantic catalyst is not susceptible to deactivation by water makes it possible to use a conventional desulfurization process on the recycle gas. The product gas from such a desulfurization operation is normally saturated with water. It has also been shown experimentally that although extreme concentrations of amines, such as might be carried over from a desulfurization unit in an upset, cause a decline in catalyst activity, this is also only a temporary effect. After reduction of the amine concentration to normal levels, the catalyst activity was immediately restored.

Experimental data have been obtained in which abnormally high concentrations of certain metals which might conceivably be found in naphtha feeds were charged over the catalyst. For example, arsenic in several volatile forms was included in the reactor feed in concentrations up to 10,000 parts per billion. No harmful effect, either temporary or permanent, was observd.

Evantually, after many months operation, physical and chemical changes in the catalyst will have reduced its activity to an undesirable extent. At this point, the catalyst will be returned to the supplier for chemical reconstitution.

We have attempted, in this paper, to show the many factors that contribute to a successful catalytic reforming process. It is our opinion that catalytic reforming will play an important part in every refiner's program to remain competitive in gasoline quality Basically, we believe that the economic success of any catalytic reforming process will be determined primarily by the catalyst employed .

References

1. *Petroleum Refiner, 30,* No. 9, 183 (1951).
2. Weber, *Oil and Gas Journal, 49,* No. 42, 129 (1951).
3. Ciapetta, F. G., U. S. Patent 2,550,531 (1951). Ciapetta, F. G., and Buck, W. H., U. S. Patent 2,589,189.
4. Fowle, et al, Advances in Chemistry Series, No. 5, 76 (1951).

* * *

CNGA Plans June Frolic

Myron B. Niesley, chairman of Entertainment Committee of the California Natural Gasoline Association, announced that this year's June Frolic would be held Saturday, June 7, at the Rio Hondo Golf Club, Downey.

New ideas and events are being planned for the Frolic this year by Niesley's committee, composed of: Fred Carter, Fisher Governor; Al Decker, Prowell-Decker; Harold Dresser, The Marley Company; Verne Frost, Materials Service Company; Jim Gesner, Reliance Division, American Meter Company; Les Gfeller, General Electric; Dick Jenkins, Clark Bros. Company, Inc.; Bill Jordan, Allied Supply; Charlie Rajnus, Ingersoll-Rand; Gordon Greene, Gordon Greene, and Bob Williamson, Cooper-Bessemer Corporation.

Chemical Plant Firm Set Up

K. C. Towe, president of American Cyanamid Company, has announced the recent formation of a new corporation, Chemical Construction (Inter-American), Ltd. A Cyanamid subsidiary, with main offices in Toronto, Canada, Chemical Construction (Inter-American), Ltd., will design and build chemical plants in all nations of the Western Hemisphere except the United States. Its operations will parallel those of another cyanamid unit, Chemical Construction Corporation, which designs and builds chemical plants in the United States and throughout the world.

President of the new company is W. R. Geddes, assistant to the president of North American Cyanamid Limited, which is wholly owned by American Cyanamid Company.

Catalyst Division Moves

Catalyst division, National Aluminate Corporation has opened sales offices in New York City at 141 East 44th Street. According to Gage Averill, sales manager of the catalyst division, the new office is being established to make it easier for eastern users of Nalcat catalyst to consult company representatives.

Phenol Plant Approved

Government approval has been obtained for a previously announced synthetic phenol plant at Richmond, California, it was announced by Standard Oil Company of California.

Standard's president, T. S. Petersen, said that a certificate of necessity granted by the Defense Production Administration covers 50 per cent of the new plant's process facilities, and 45 per cent of auxiliary facilities.

All research necessary to operation of the plant has been completed, Petersen said, and design work is approaching completion. This addition to Standard's Richmond refinery will be the first synthetic phenol plant in the West. It will produce phenol and acetone for Standard's subsidiary, Oronite Chemical Company, using a recently-developed synthesis process in which neither sulfuric acid nor chlorine is used.

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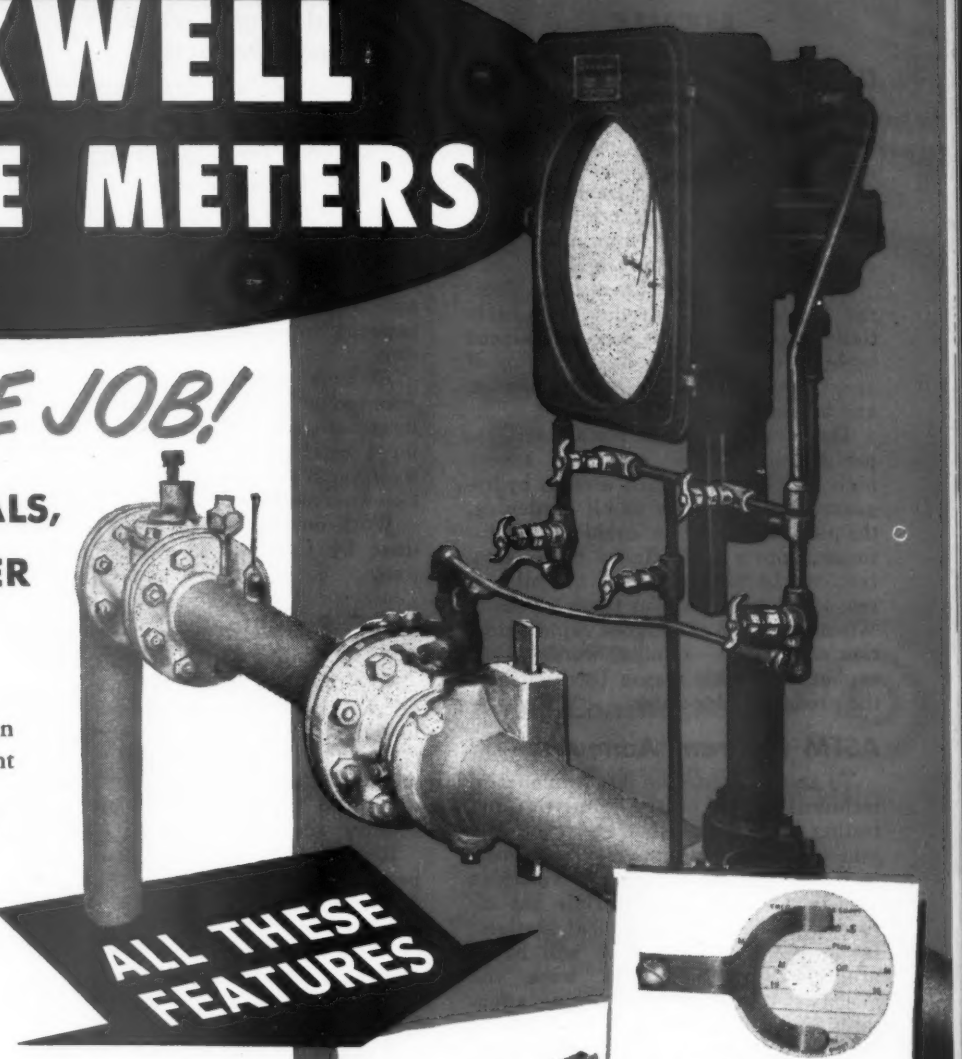

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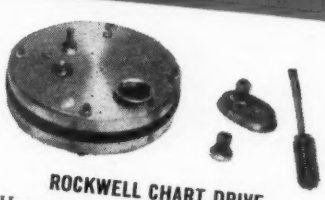

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NEWS

Davison Now Produces Raney Nickel Catalyst

Production of Raney nickel catalyst, used in industrial hydrogenation operations, has begun by The Davison Chemical Corporation in its specialty catalyst plant at Curtis Bay (Baltimore), the company announced.

The product, named after Dr. Murray Raney, its first producer, is essentially a spongy form of nickel, produced by leaching aluminum from an alloy of approximately 50 per cent aluminum and 50 per cent nickel.

The resultant catalyst has a maximum particle size of 140 mesh and a very high surface area. When used in hydrogenation, also known as oil hardening, the process by which a liquid oil is transformed into a solid, Raney nickel catalyst can be filtered out of the oil and reused as many as 250 times or more. When it dries it undergoes rapid oxidation and ignites—in other words, is pyrophoric. For this reason Davison ships the product under water.

ASTM Program Announced

To accommodate the large number of technical papers on the properties and testing of materials that are to be presented at its 50th anniversary meeting in New York, June 23-27, the American Society for Testing Materials has already scheduled 30 technical sessions. In addition to these there will be in progress throughout the week the Society's 10th exhibit of testing apparatus and laboratory supplies and its 8th photographic exhibit. Headquarters will be at the Hotels Statler and New Yorker, with exhibits at the Statler.

Ashland Begins Work To Enlarge Refineries

Ashland Oil and Refining Company has reported the beginning of field work on new facilities at its Catlettsburg, Kentucky, and Tonawanda, New York, refineries. In Catlettsburg, the principal work involves a 11,000-bbl per day vacuum unit to produce gas oil for catalytic cracking feed from reduced crude. A new synthetic crude tower will permit an increase in catalytic cracking capacity from 22,000 to 27,000 bbl per day.

At Tonawanda there will be extensive revamping of existing equipment to meet new process requirements, including a catalytic poly unit, and kerosine treating. Work is scheduled for completion around the end of 1952.

Work on the two refineries is being done by Catalytic Construction Company.

AIOC Refining Capacity Up

Anglo-Iranian Oil Company has reported that by 1953 its three major refineries in Britain—Llandarcy, Grangemouth, and Kent—will have a combined capacity of 205,000 bbl a day. This will make the company the biggest producer of refined petroleum products in that country, according to an AIOC report.

Reports from refineries on the European continent operated by the AIOC's associated companies indicate that they are running at a combined rate of approximately 150,000 bbl a day. L'Avera and Dunkirk (both operated by the AIOC's French associates, the Societe Generale des Huiles de Petrole BP) and Antwerp, jointly owned by AIOC and Petrofina, are each around the 40,000-bbl a day mark.

Construction Begins On Bahia Refinery Expansion

Construction has begun on the expansion of Brazil's first modern refinery, completed in 1950 at Mataripe in the state of Bahia, it was announced by the M. W. Kellogg Company.

The expansion will double the capacity of the present 2500 bbl per day combination thermal refinery. It will also include catalytic polymerization, which will raise the overall octane rating of the finished gasoline, as well as facilities for production of LPG. As Brazil's crude has thus far proved to be "sweet," the only pre-polymerization treating step will be caustic washing to remove the small amount of sulfur remaining in the gaseous charge stock.

Modifications in the original plant, built for Conselho Nacional do Petroleo, are being made to process the lighter crudes which are now available from local fields in the area. The completed plant will include topping, vis-breaking, thermal reforming and cracking, stabilization, and light ends recovery, in addition to the cat poly, caustic treating, and LPG facilities.

Leonard Refineries Expands

Leonard Refineries in Alma, Michigan, has announced that field work is proceeding on extensive additions to increase the plant capacity. The work, which is being done by Catalytic Construction Company, includes installation of a new synthetic crude tower and additions and revamping of the gas plant. This installation will make it possible for Leonard to process 7000 bbl of oil per day of gas oils in its catalytic cracking unit, which originally had a rated charge capacity of 3000 bbl.

New Kent Refinery. An artist's impression of the Anglo-Iranian Oil Company's new Kent refinery on the Isle of Grain, near London, as it will appear when completed. Construction began in 1950. It is planned that the refinery, which is due to go on stream with a production of 42,000 bbl a day this summer, will be running at its full capacity of 84,000 bbl a day by the end of the year.

New Lubricant Announced After 5 Years Experiment

A permanent suspension of finely divided lead metal in greases, lead which is actually in dust form, has produced a lubricant that is a homogeneous blend and that offers decided advantages, according to Knapp Mills, Inc. The homogenizing process was worked out finally, and a careful selection was made of the proper base grease that will maintain the lead in suspension.

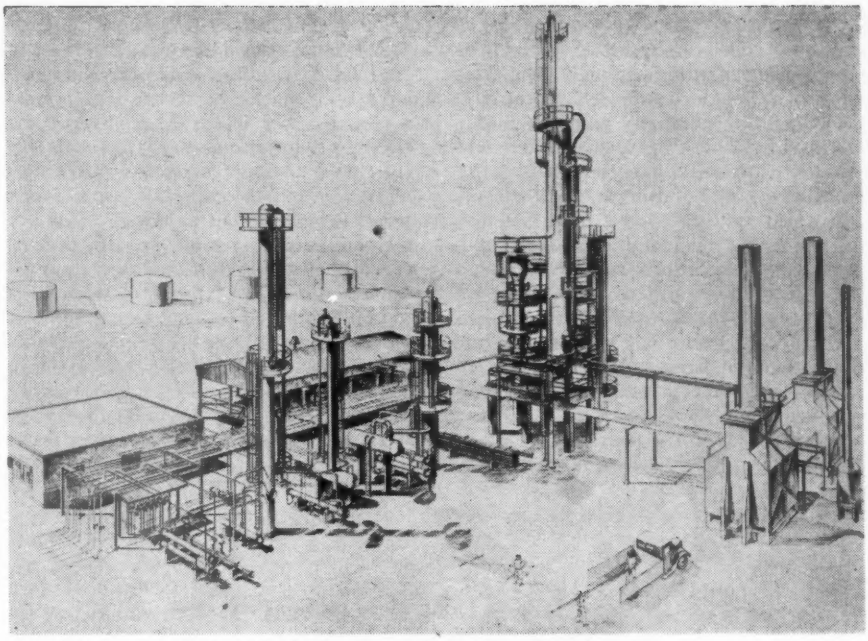
The lead coats surfaces of rubbing parts with a protective layer that protects the surface underneath both from frictional damage and from corrosive action, lead being impervious to many corrosive chemical agents. It is said to fill pits and cavities in old bearing surfaces to rebuild them to an efficiency approaching that of the new surfaces. Lead-Lube has been developed through a period of five years in collaboration with 100 companies testing the products.

DPA Tax Certificates Near Half-Billion Dollar Mark

The Defense Production Administration has granted new certificates for accelerated tax amortization for oil and gas expansion totalling close to $500,000,000 during the two weeks ended March 20.

Eight certificates were granted for projects that exceeded $20,000,000. Seven of these were in the oil and gas industry. Atlantic Refining Company was given the largest certificate for product manufacture. It was granted percentage write-offs on $29,500,000 for aviation alkylate at Philadelphia.

Of the total 564 certificates issued, 116 were for oil and gas projects aggregating $447,604,000. Thirty of these certificates were issued in the refining industry and are listed below:



Pan-Am Southern's fluid hydroformer at Destrehan, Louisiana.

First Fluid Hydroformer Now Under Construction

Construction has begun at the Pan-Am Southern Corporation's fluid hydroformer at the company's Destrehan, Louisiana refinery. Reported to be the world's first fluid hydroformer, the plant is a 2000-bbl a day unit.

Dr. Robert E. Wilson, chairman, and A. W. Peake, president, Standard Oil (Indiana) of which Pan-Am is a subsidiary, reported that fluid hydroforming may in time prove almost as important as the fluid catalytic cracking process. It will produce high octane motor gasoline blending stock, in strong demand for both military and civilian use. Operated under more severe conditions, it is capable of producing avgas base stocks with aviation octane ratings of 98 (F-3) and more than 175 (F-4) with the addition of 4.6 cc of TEL per gallon. The process may also be used to produce aromatic materials.

The main group of vessels in center of drawing is reaction-regeneration section. The reactor is the largest vessel; atop it is the spent catalyst stripper. Left of the reactor is the regenerator; behind it stands the catalyst storage drum. The unit's other principal components (left to right) are: Control house; compressor house; three recovery towers comprising main fractionator, absorber and stabilizer; the reaction-regeneration section; the naphtha furnace; the recycle gas furnace; and the blowback air heater.

Name of company Location of facilities	Product or service	Estimated cost
H. W. Bass & Sons, Inc. Live Oak County, Texas	propane and butane	$1,925,530
Bel Oil Corp. Elton, Louisiana	natural gasoline	145,000
Esso Standard Oil Linden, New Jersey	isobutylene, polybutene, additives for lubricating oils	8,529,000
Lubrizol Corporation Wickliffe, Ohio	detergents for lubricating oils	548,473
Magnolia Petroleum Longville, Louisiana	natural gasoline natural gas	705,900
Mayfair Minerals, Inc. Port Isabel, Texas	products	1,831,963
Old Dutch Refining Co. Muskegon, Michigan	benzene and toluene	326,100
Phillips Oil Co. Kansas City, Kansas	propane	467,000
Phillips Petroleum Co. Gray County, Texas	natural gasoline	92,000
Phillips Petroleum Co. Hutchinson County, Texas	natural gasoline	95,228
Phillips Petroleum Co. Brazoria County, Texas	natural gasoline	240,000
Phillips Petroleum Co. Borger, Texas	natural gasoline	732,000
Quimico Contra Costa County, Calif.	tetraethyl lead	1,267,000
Scurlock Oil Company Sabine Pass, Texas	products	323,976
Shell Chemical Corp. Martinez, California	detergents for lubricating oil	790,000
Shell Chemical Corp. Houston, Texas	ethyl chloride	9,500,000
Shell Oil Company Notrees, Texas	natural gas processing	1,140,000
Sid Richardson Gasoline Winkler County, Texas	propane and butane	600,000
Skelly Oil Company Carter, Stephens Counties, Okla.	natural gasoline	1,100,000
Skelly Oil Co. Lea County, New Mexico	natural gasoline	2,500,000
Standard Oil Texas Snyder, Texas	isobutane and natural gasoline	941,000
Standard Oil California Richmond, California	lubricating oils	470,000
Standard Oil Indiana Wood River, Illinois	additives for motor oils	1,500,000
Stanolind Oil and Gas Hockley County, Texas	gas processing	1,076,000
Taylor Refining Co. Port Isabel, Texas	refined products	1,302,375
The Texas Company Scurry County, Texas	propane, butane, natural gasoline	3,760,000
Warren Petroleum Corp. Monument, New Mexico	natural gasoline	80,426
Warren Petroleum Corp. Maysville, Oklahoma	propane and butane	1,451,472
Warren Petroleum Corp. McLean, Texas	natural gasoline	91,933
Wilmington Gasoline Co. Los Angeles, California	natural gasoline	292,000

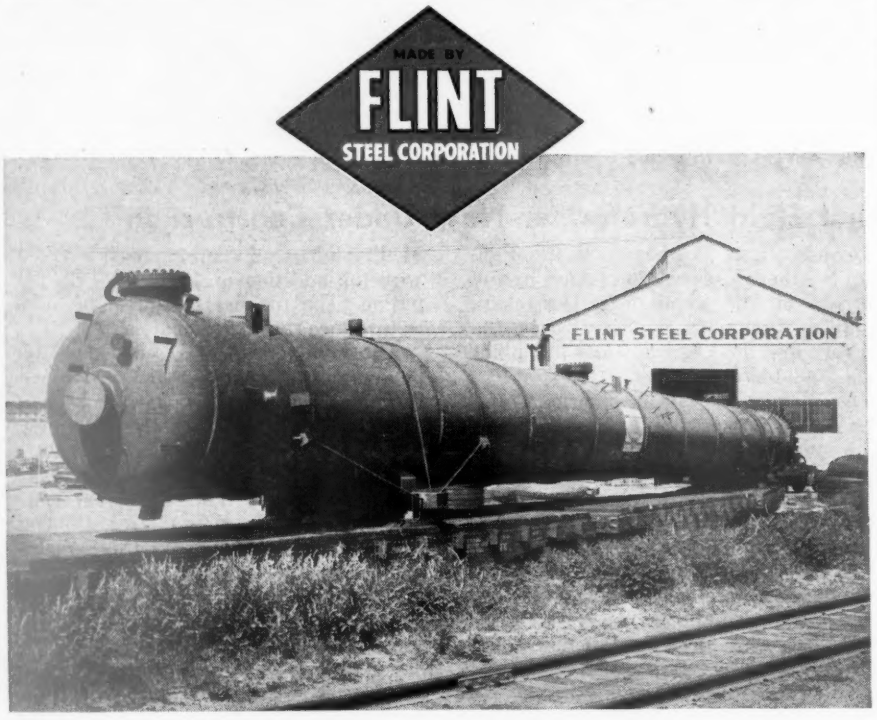
AIOC Develops New Process

A new catalytic desulfurization process called "Autofining" has been developed by Anglo-Iranian Oil Company, according to a company announcement. Operating at low pressure, the new patented process has flexibility for handling a range of different feed stocks. Hydrogen manufacturing facilities are *not* required, the company stated, and catalyst regenerations are infrequent. The "Autofining" process is a result of intensive research and development work and has been fully proved in large pilot plant operations. A commercial unit is being erected at one of the company's refineries and is due to be commissioned later in the year.

TEL Limitations Removed

All limitations on the use of tetraethyl lead fluid in automotive gasoline have been removed by direction of Secretary of the Interior Oscar L. Chapman, Petroleum Administrator for Defense. Unrestricted use of tetraethyl lead fluid (TEL) is possible now for two reasons, Secretary Chapman said: (1) The Petroleum Administration for Defense has reached an understanding with the military on the size of the reserve of TEL to be maintained to meet foreseeable requirements of the military and civilians. (2) Adequate supplies of raw materials have been made available and production facilities have been increased.

TEL increases antiknock qualities.



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Humble Will Construct New Paraxylene Plant

Humble Oil and Refining Company's projected new paraxylene plant at its Baytown, Texas, refinery is a new addition to the Gulf Coast area's expanding petrochemical industry. The plant, scheduled for completion in May, 1953, will produce more than 2,000,000 lb of paraxylene a month.

Construction gets underway in September, and materials are already being purchased by C. F. Braun Construction Company.

Paraxylene, one of the raw materials for the new synthetic fiber, Dacron, is separated from mixed xylenes by a special process developed by Humble research engineers. Not all crude oils are sources of xylenes, but those from fields in the Gulf Coast area are considered good. The natural supply, however, is small in comparison with the volume that can be produced synthetically.

Plans Laid for Expanding Poland Chemical Industry

The government contemplates that the chemical industry shall be, next to mining, the greatest industry in Poland, according to International Petroleum Trade, a U. S. Bureau of Mines publication.

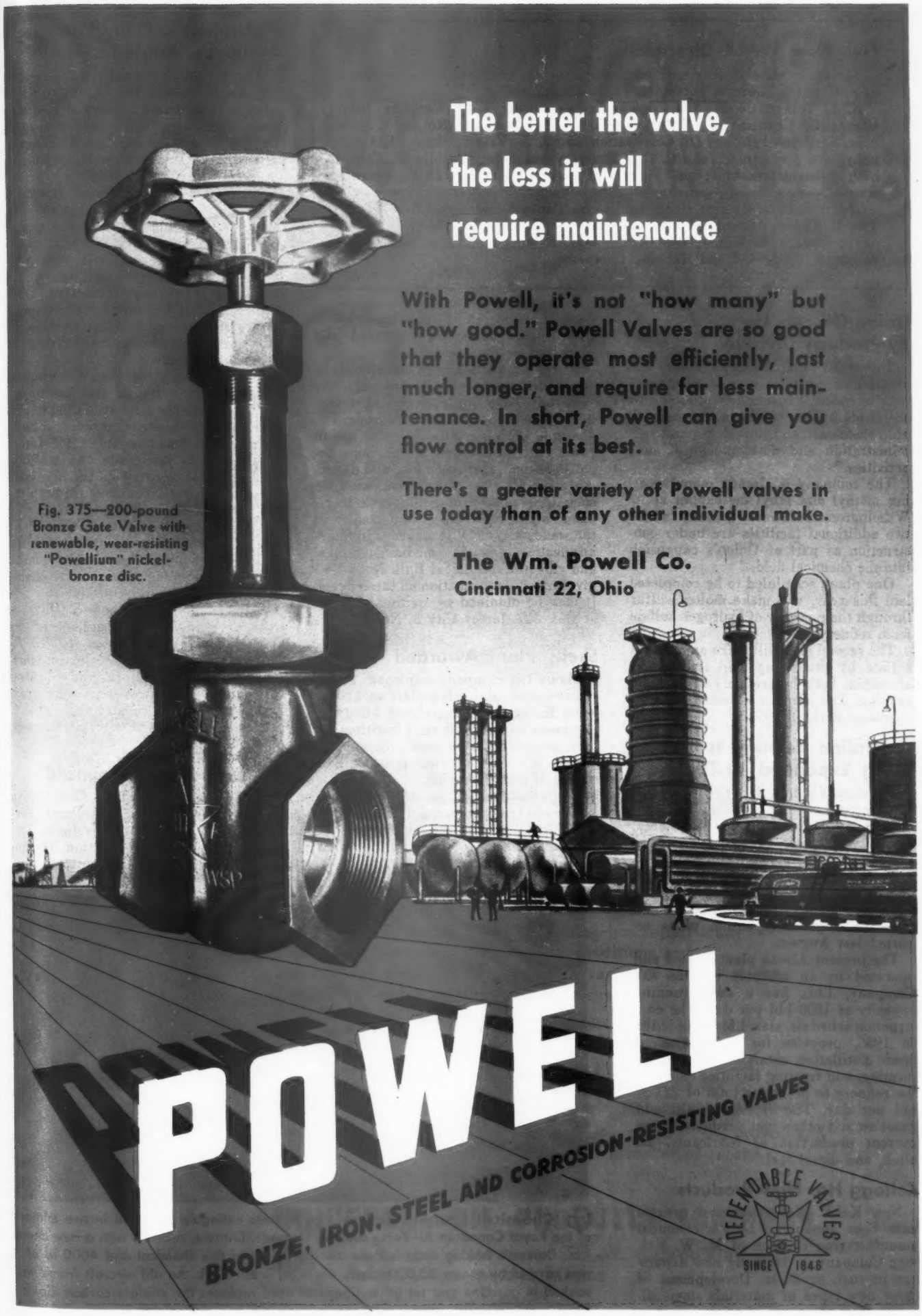
Under the Polish Six-Year-Plan, it expects to increase production for the entire chemical industry about 3½ times the output in 1949. Synthetic "heavy chemistry" will play a special part in this increase. Plans include the erection or expansion of plants for the preparation of synthetic gasoline, synthetic rubber, synthetic fatty acids, detergents, and various kinds of artificial fabrics. The production of synthetic gasoline alone is raised in 1955 to 6 times the amount produced in 1949.

Also from Poland the Bureau reports that a modern petroleum refinery with a capacity amounting to four times the total production of the previous Polish refineries, is under construction. Date for beginning operations has not been announced, but is expected to be soon.

Snell Gets Scroll Award

The fourth annual Honor Scroll Award of the New York Chapter of the American Institute of Chemists will be presented this year to Dr. Foster Dee Snell, president of Foster D. Snell, Inc., consulting chemists. The announcement was made by Dr. Henry B. Hass, chairman of the New York section.

The Honor Scroll, given annually for outstanding contributions to the profession of chemistry, will be presented to Dr. Snell at a dinner meeting in the Hotel Commodore, New York, May 22. Dr. Gustav Egloff, director of research of the Universal Oil Products, Chicago, will speak on "Foster D., As I Know Him"; Karl M. Herstein, Herstein Laboratories and chairman-elect of the New York section, will make the presentation of the scroll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DEPENDABLE VALVES
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Five New WPRA Directors!

The entire slate of officers of the Association was reelected at San Antonio, as well as the Board of Directors. These officers are:

R. L. Tollett, Cosden Oil Corporation, president; H. J. Kennedy, Continental Oil Company, F. L. Martin, Sunray Oil Corporation, Roland V. Rodman, Anderson-Prichard Oil Corporation, and J. W. Vaiden, Skelly Oil Company, vice presidents; John C. Day, secretary-treasurer; Virginia W. Campbell, assistant treasurer; and Fayette B. Dow, Washington, D. C., general counsel.

The new directors are: Bruce K. Brown, Pan-Am Southern Corporation; Max M. Fisher, Aurora Gasoline Company; F. W. McCurry, Derby Oil Company; Everett F. Wells, Ashland Oil and Refining Company, and G. G. Woodruff, Globe Oil and Refining Company.

Union Oil Sets Up By-Products Division

Union Oil Company of California has announced establishment of a by-products chemical division to "process raw materials and by-products into marketable chemicals, and provide separate administration and development of such activities."

The company is already manufacturing methyl and ethyl mercaptan at its Wilmington, Delaware, refinery where two additional facilities are under construction as part of Union's expansion into the chemical field.

One plant, scheduled to be completed late this year, will make molten sulfur through the recovery of hydrogen sulfide from refinery gases.

The second unit will make ammonium sulfate by processing acid sludge and ammonia, both by-products of gasoline refining. The plant is expected to be in operation early in 1953.

Australian Refinery Is Being Expanded 11-Fold

Standard-Vacuum Oil Company has announced further plans for expansion of Altona Refinery near Melbourne, Australia, calling for an eleven-fold increase in capacity and an additional investment of $30,000,000. The new program represents nearly a 50 per cent jump in both plant size and investment over the original expansion plans reported last August.

The present Altona plant, owned and operated by an affiliate, Vacuum Oil Company, Ltd., has a crude-running capacity of 1800 bbl per day. The construction schedule, slated for completion in 1955, provides for installation of crude distillation, catalytic cracking, reforming, and treating facilities enabling the refinery to process a total of 22,000 bbl per day. The expansion will add gasoline and other fuel products to the current production of lubricants, asphalt, and diesel fuel.

Kellogg Has New Products

New Kel-F oils, waxes and greases have been announced by the chemical manufacturing division of M. W. Kellogg Company, a distinctly new departure in such products. Development of these new types of materials stems directly from the work of researching on plasticizers for Kel-F, the fluorocarbon plastic now being manufactured and marketed by the same division.

These products are chemically inert, can withstand practically any corrosive material, have high electrical resistance, and high temperature properties. The oils are especially suited to use in cable and transformer applications because of their heat resistance and dielectric strengths. Greases are indicated for such uses as stop and plug-cock lubricants where inertness is important and the waxes may be advantageous in many application as sealing media, coverings, and closures. Technical Bull. No. 5-1-52 gives specific information on these items. It may be obtained by writing Kellogg at Box 469, Jersey City 3, New Jersey.

Skelly Plant Awarded

Skelly Oil Company employees at the refinery and lubricating plant at El Dorado, Kansas have completed 1,000,000 manhours worked without a lost-time injury, according to an announcement by James W. Vaiden, vice president in charge of manufacturing.

Skelly held a special celebration at El Dorado recently awarding certificates of achievement to each employee who participated in crossing the 1,000,000 manhours milestone.

Australian Refinery Plans Made by Anglo-Iranian

Further details have been released by the Anglo-Iranian Oil Company of its plan to build a new refinery at Kwinana near Fremantle, following ratification by the Western Australian Parliament of the agreement between the state government and the company.

An Anglo-Iranian official stated in New York that plans call for the construction of a plant with a capacity of 60,000 bbl a day, which will be the largest in Australia and will cost $89,600,000. It will provide for Anglo-Iranian's Australian bunkering trade through BP (Australia) Ltd. Concurrently the storage and distribution facilities of Commonwealth Oil Refineries are being increased.

The Western Australian Government welcomed the proposal and has undertaken to make the land available, to supply fresh water and electricity to build some 1,000 houses suitable for future employees, to lay roads and railways to the site and to carry out the necessary dredging of water channels through the Success and Parmelia sandbanks.

The plant will consist of atmospheric and vacuum distillation units with the usual accompanying treatment plants. Catalytic cracking plant will enable high-grade petrol to be produced

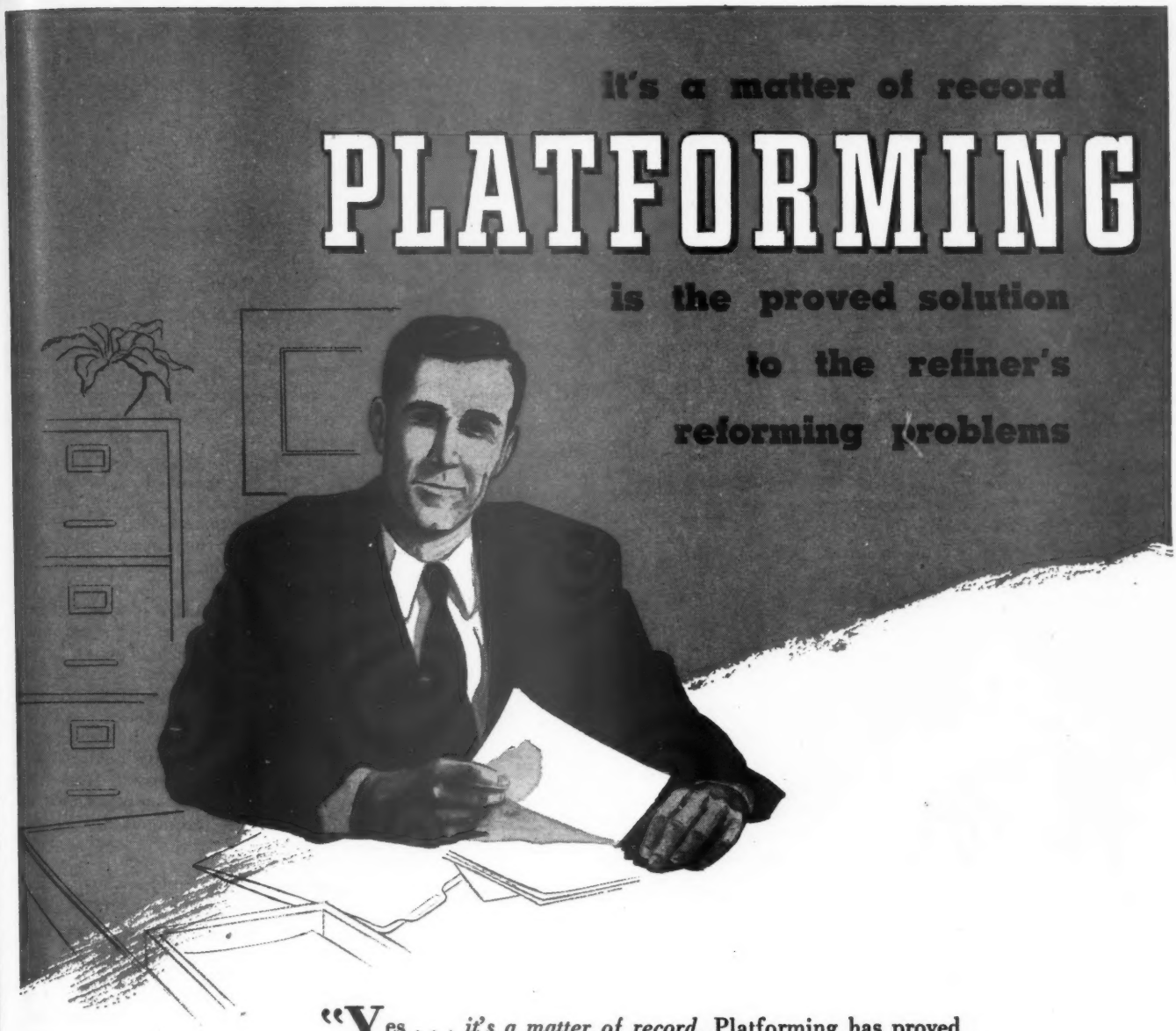
It is estimated that about 500,000 lbs of steam and 5,000,000 gallons of sea water for cooling purposes will be required every hour. A powerhouse, maintenance workshops, stores and a laboratory equipped with test engines for product control will be constructed.

Some 80,000 tons of steel will be needed for the job.

Name Change Announced

The name of Consumers Cooperative Refinery Association of Levelland, Texas, has been changed to Levelland Consumers Cooperative Association. The announcement was made recently.

Dry Chemical Demonstration. Fire fighters extinguished a fire in two minutes at the Royal Canadian Air Force Station, Uplands, Ottawa, recently with a new chemical. Domestic baking soda is the main ingredient of this chemical and 4000 lb of it was carried by a new 33,000-lb dry chemical crash truck. An old aircraft frame was soaked in gasoline and set afire. Chemical used replaces the straight carbon dioxide foam, used previously, and is used for gasoline, oil, and electrical fires.



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It's a matter of record that more than one refiner has met the demand for premium gasoline by merely increasing the severity of processing conditions and producing a higher octane Platformate . . . and that sales departments thank Platformed gasoline for wider markets and bigger gallonage.

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PERSONALS

W. V. Cropper has been promoted to assistant chief chemist of the Standard Oil Company (Indiana) research laboratories at Whiting, Indiana. He has been succeeded as group leader at the company's Casper, Wyoming, laboratory by **H. M. Schauer**, formerly chemical engineer at Whiting.

Cropper joined Standard in 1942 as a chemist at Whiting. In 1944 he was transferred to Casper, where he became group leader in 1946. He is a graduate of the University of Kentucky and received a master's degree from Kentucky Wesleyan college. Schauer joined the company in 1946 as a chemical engineer at Whiting. He was graduated from Iowa State college.

Henry E. Craven, Jr.

Henry E. Craven, Jr., has been named manager of the newly organized Lake Charles, Louisiana, division of the Davison Chemical Corporation. The new division will operate the large plant, which the company is building on the Calcasieu River south of Lake Charles, and which will produce petroleum cracking catalyst and other chemicals.

Craven is a graduate in ceramic engineering of North Carolina State College. He was with the Pemco Corporation of Baltimore before the war.

Morris T. Carpenter, former administrative director of research, Standard Oil Company (Indiana), has been named assistant director of the refining division of the Petroleum Administration for Defense, succeeding **Walter C. Huffman** of Wallingford, Pennsylvania, Secretary of the Interior Oscar L. Chapman announced.

Carpenter has been serving in PAD as a special assistant to the director of the refining division since January 1952. A graduate of the University of Kentucky with a degree in industrial chemistry, Carpenter has been engaged in various phases of petroleum refining since 1930.

Huffman, whom he replaces, joined PAD's staff in October 1950 as an aviation-fuels technologist. In December 1950 he was named assistant director of PAD's aviation-fuels program, and a year later he was named assistant director of the Refining Division. He is leaving PAD to return to the Sun Oil Company, where he will assume new duties in the manufacturing department.

L. W. Russum has been promoted to section leader heading the process economics section of the process division, at the Standard Oil Company (Indiana) Whiting, Indiana, research laboratories. **W. E. Kennel** has been advanced to group leader of the process design and economics group of the chemical products division to succeed Dr. Russum. **E. W. Kane** has been promoted to group leader in the process economics section of the process division.

Dr. Russum joined Standard in 1947 as a chemical engineer and became group leader in 1948. He is a graduate of the University of Arkansas and received his doctor's degree from Massachusetts Institute of Technology.

Dr. Kennel became associated with the company in 1948 as a chemical engineer. He did his undergraduate work at the University of Illinois and received a PhD degree from M. I. T. Kane joined the company in 1947 as a chemical engineer. After graduating from Case institute he received a master's degree from MIT.

John B. Hanna has been named general superintendent of the new refinery, which Standard-Vacuum Refining Company of South Africa (Pty.), Ltd., will build at Durban, Union of South Africa. Until recently Hanna was supervisor of maintenance and construction at Esso Standard Oil Company's Bayway Refinery. A native of Fort Wayne, Indiana, he is a graduate of the University of Pittsburgh where he received a bachelor of science degree in petroleum engineering. Hanna joined Esso Standard in 1935, and transferred to the Standard-Vacuum Oil Company's South African affiliate early this year.

Herman L. Shaw has been named president and general manager of Shaw Oil and Chemical Corporation, Boston, Massachusetts. With many years of experience in the chemical industry, Shaw was formerly president of H. L. Shaw and Sons, Inc.

J. G. Leach has been appointed senior technologist to assist in the process department of Shell Oil Company's head office in New York. Leach, who joined the company in 1944 at the Montreal refinery was transferred to the technological department in 1946. **G. Stegmayer** has been named supervisor of formulation and products surveys at the Montreal refinery laboratory. **A. V. Doyle** has been transferred to the Montreal refinery as senior assistant to the chief technologist.

Wayne C. Edmister

Wayne C. Edmister, widely known petroleum process engineer and until recently professor of chemical engineering at Carnegie Institute of Technology, Pittsburgh, has resigned and will join the staff of California Research Corporation in Richmond, California. California Research Corporation is a subsidiary of Standard Oil Company of California.

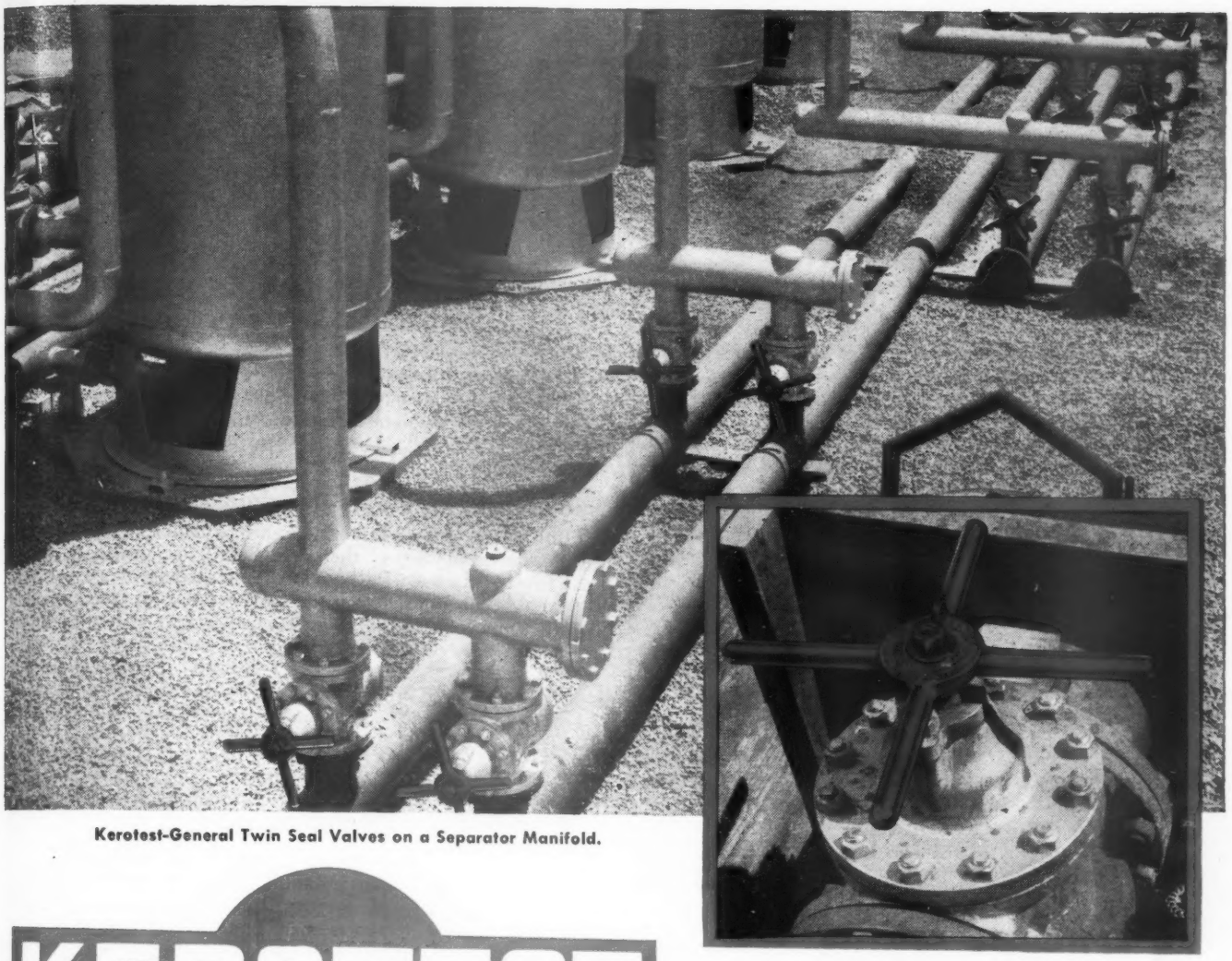
Edmister is the author of a large number of papers, articles, and other published material in his field, is an active member of the American Institute of Chemical Engineers and of other technical and scientific societies, and for years has been one of the leaders in research and development in the petroleum and allied industries, with particular emphasis on applications of thermodynamics, fractional distillation, and design.

A. Wesley Hoge will be in charge of process design and **David B. Ardern** will be in charge of technical service, Houdry Process Corporation.

Joining the Houdry organization in 1943, Hoge has continuously served in the technical service division of the company. His activities have included supervision of the initial operation of newly-licensed commercial units and the continuous plant surveys and direct assistance which Houdry affords its licensees. He attended Wittenberg College and is a graduate of Ohio State University, from which he received a BS degree in Metallurgy. He is a member of ACS and Sigma Pi.

Ardern joined Houdry in 1942 and has been primarily engaged in process design, concentrating on the commercial design of Houdriflow moving-bed catalytic cracking units and the more recent Houdriforming units for catalytic reforming of petroleum naphthas to aromatics and high octane gasolines. He received his BS and MS degrees in chemical Engineering from the University of Louisville. He is a member of ACS and AIChE.

Wilma M. Vogt has been employed as a chemist in the development and research department, Hooker Electrochemical Company, Niagara Falls. **Orville R. Hicks** has joined the engineering department as a draftsman, and **Frank L. Echelberger** is employed as a chemist in the works laboratory.



Kerotest-General Twin Seal Valves on a Separator Manifold.

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GASOLINE	LIQUID NITROGEN
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The Kerotest-General Twin Seal Valve is recommended for gas and liquid service in a pressure range up to 5000 psi at 200° F. Seats shut off vapor-tight—no galling or scoring. Operates *without lubrication.* Special trims are supplied for corrosive service.

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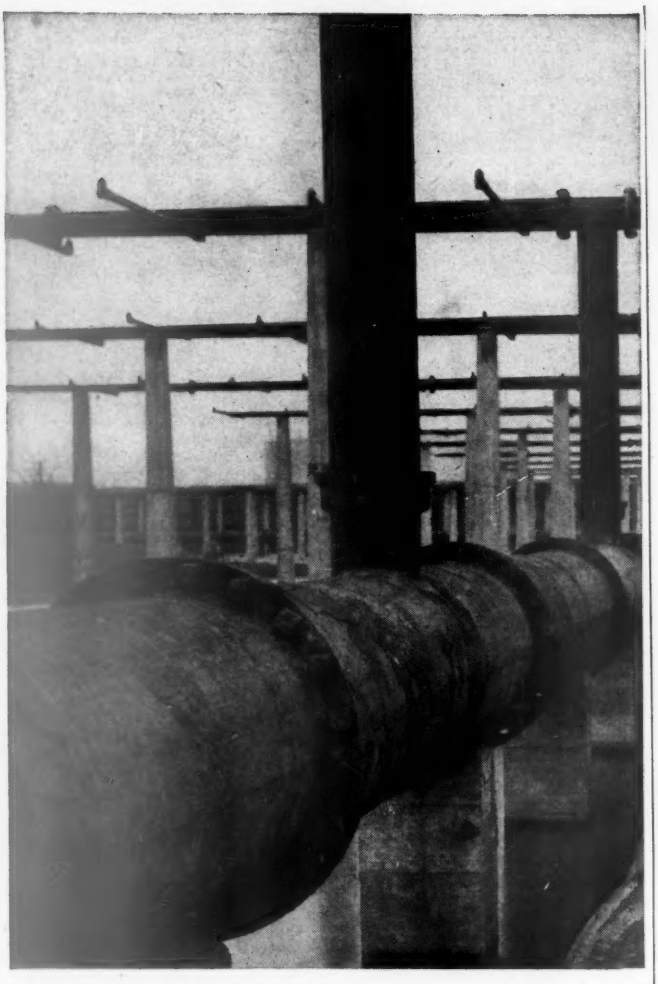


AN ECONOMY FACTOR
IN REFINERY OPERATION

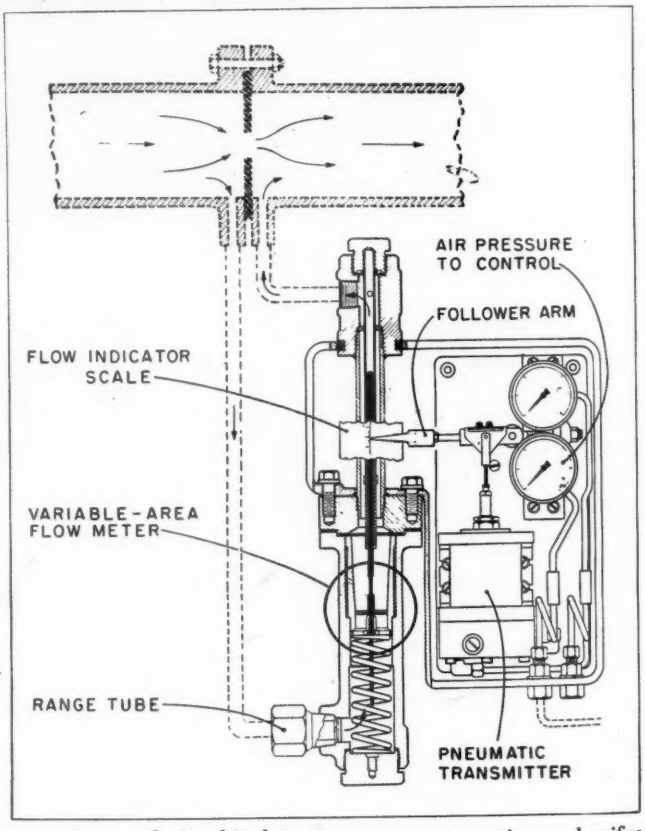
Proved long life and stubborn resistance to corrosion make cast iron pipe a contributing factor in lowering plant maintenance per barrel of crude. Replacing shorter-lived pipe with cast iron pipe has demonstrated this in many refineries. Cost per term of service decreases. Interference with production, caused by frequent replacements, ceases to be a headache. Cast iron pipe works hand-in-glove with plant management to keep maintenance cost down in many refinery operations. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints. Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois.

CAST IRON PIPE
FOR LONG LIFE AND ECONOMY

Willis F. Sims, center, chemical plants division, Blaw-Knox Construction Company; back to camera are: R. D. McCrum, Cooperative Refinery, Kansas City (right), and Martin L. Dowell, sales engineer for Blaw-Knox. They were snapped at the Western Petroleum Refiners Association meet.

New Orifice Meter Is Developed

Introducing a new principle in orifice metering, Fischer and Porter have announced their VA Cell. This measures, kinetically rather than statically, a stream bypassing the orifice. The linear relationship between the bypass flow and the main flow makes for simplicity and greater accuracy, eliminating the



square-root relationship between manometer action and orifice flow. The actual flow in the bypass results in less freeze-up in cold locations, eliminates condensate "pots," affords higher linear-scale chart accuracy, and wide "rangeability" to meet operating conditions changes.

The cell is connected across the orifice plate and can handle pressure differentials as high as 1400 in. of water column (about 3.4 atmospheres, or 50 psig). The fraction of total flow through the bypass is proportional to the pressure differential. The float rides at a level proportional to the flow, carries two small Alnico magnets coupling it to the follower arm yoke and the pneumatic transmitter translates the arm's position into air pressure, which signals the receiver instrument. Different range tubes allow a differential range from 50 to 1400 in. of water pressure. The cell is available from the manufacturers at Hatboro, Pennsylvania, at a price of $252.

EXCLUSIVE

The Trend in PIPE LINE DESIGN AND OPERATION

Greater automatic control, increased instrumentation, the use of minimum amounts of steel, these are among the advances that will be a part of the future scene

W. C. KINSOLVING

PIPE lines, now operated at an amazingly high level of productivity compared with all other forms of transportation, are ranging strongly toward more and more automatic operation and control.

This is a typical development, reflecting the aggressive forward-thinking that has stimulated technological progress in the pipe line industry and made it one of the fastest-growing large businesses in the country today.

More than 12,000 miles of line pipe were laid last year by the industry and an equal mileage plus a thousand or so is forecast for 1952.

It follows that with such growth—and the industry keeps bumping its head against the steel ceiling or there would be considerably more — every modern technological advance will be taken advantage of.

Engineering and operating techniques are under constant study and review. Many of the principles already are established but numerous refinements in procedure remain to be discovered.

It can be stated that in the future no pipe line of any consequence will be built without using beamed radio (microwave) in its operation.

At the same time, there will be a strong trend toward increased instrumentation.

While the importance of the human element in actual routine operations cannot be discounted, the fact remains that advancing engineering has enabled pipe lines to proceed with their normal function of delivering crude, products, or gas with less and less manual attention.

Basically, of course, the consideration foremost in the minds of competitive pipe lines is efficient operation at the lowest possible cost.

It follows that use of unattended stations and remote control installations depends on the ratio of their cost to that of manual operation.

Another important phase of the industry's advance is its trend toward use of minimum amounts of steel.

Scientific progress in certain phases of pipelining, such as electrolysis prevention, has been bolstered by sound engineering studies leading to decreased need for extra steel in pipe walls.

Pipe line engineers are keenly aware of the critical supply of steel, as well as the important factors of cost.

As a result of these studies, pipe line engineers have developed the design of lines to more closely conform to the actual hydraulic pressures required in various sections of the line. In other words, the principle of "telescoping" has been further extended. Thus, the old accepted working pressure safety factor of 4 to 1 has been reduced to 1.75 to 1.

Diminishing the pipe wall thickness as line pressure declines will save many thousands of tons of steel—an invaluable contribution today when steel is in such short supply.

The industry will continue to re-check specifications and to trim its construction costs through such means as tapered lines until the law of diminishing returns makes it economically impractical.

Another great advance in the industry has been the method of licking the big-river crossings.

Better and deeper dredging methods at river crossings have about solved line-breakage, with the consequence that engineers now can pretty well predict the permanency and safety of a line crossing.

If permitted sufficient steel by the Government, the industry will continue to grow in answer to the seemingly endless demand of consumers in this country.

As it grows, operating and engineering will continue to advance with it, meeting new problems as they arise. ★

The Author

W. C. Kinsolving is president of Sun Pipe Line Company; chairman of the board of the Mid-Valley Pipeline Company and a director of the West Texas Gulf Pipe Line Company. He joined the staff of Sun Oil Company immediately upon receiving a degree in electrical engineering from Cornell University. This was in 1923 and he was an ordinary oil-field hand. Advancing through various stages of oil-field work, eventually he was placed in charge of construction of a products pipe line in the East (1930-31). He then went to Texas to direct the construction and operation of a crude oil line from the newly discovered East Texas field to the Gulf Coast. In 1942 he was called to Washington to serve as assistant director of transportation for the Petroleum Administration for War. In this capacity he figured prominently in the planning and construction of the "Big Inch" and "Little Big Inch" pipe lines. Later he was commissioned a colonel in the Army Corps of Engineers and played a prominent role in the building of the China-Burma-India pipe line. Upon completion of this war service he returned to Sun as manager of all pipe line operations, later becoming a president.

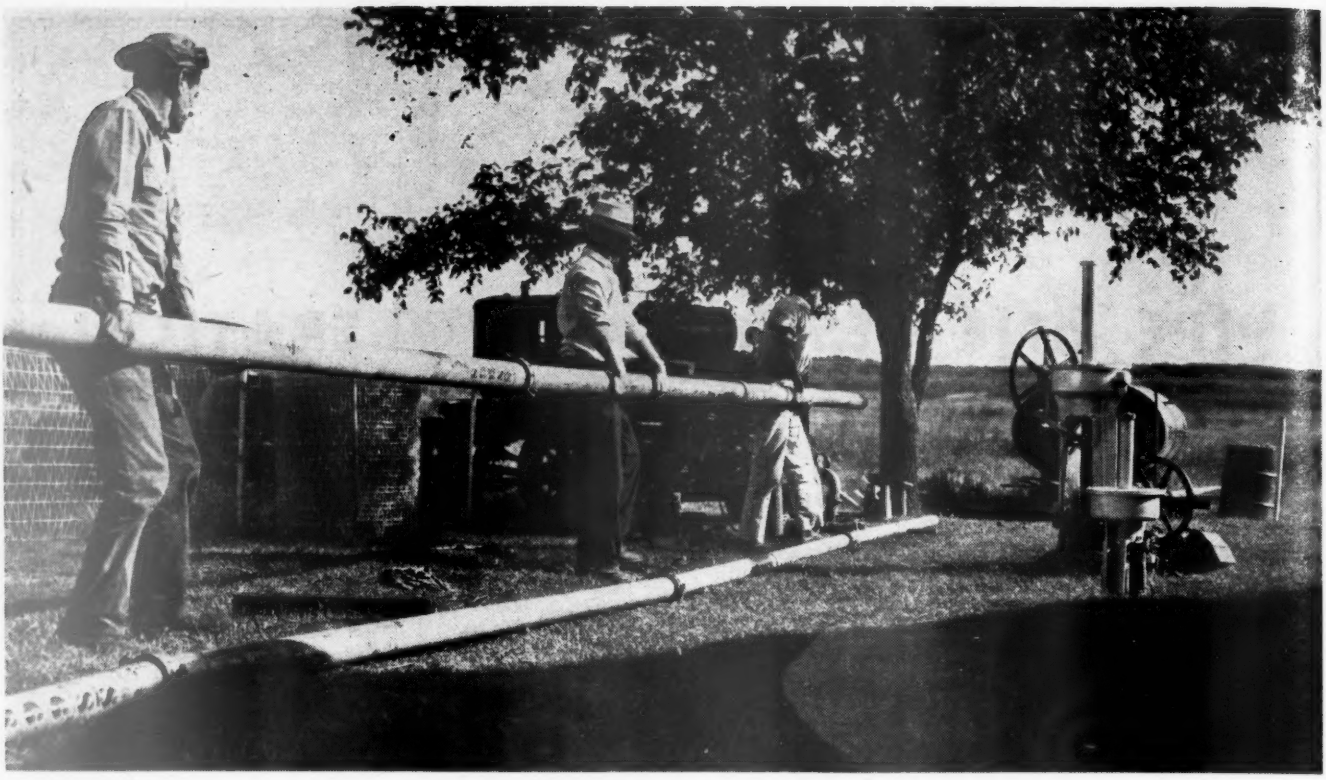


FIG. 1. Portable pumping unit and other equipment used in testing operations.

Pressure Testing Pipe Line With Oil

New technique gives greater flexibility in pumping schedules, and work can be done with minimum loss in the line throughput

A. M. HILL

A NEW technique to test an operating line for leaks has been devised by the Maintenance Department of Service Pipe Line Company. In applying it to several hundred miles of line it was found to have a number of distinct advantages. Although many pipe lines have been pressure tested with oil, it has been common practice to use water as a testing fluid to minimize damage to property caused by leaks and split joints. Testing with oil gives greater flexibility in pumping schedules, and by careful planning it is possible to carry on line testing and repair work with not more than 40 per cent loss in line throughput.

With the procedure used by Service Pipe Line Company, testing operations were carried on during the regular working day. Temporary or permanent repairs were made to leaks before close of the day's work so that gate valves could be re-set at the stations and intermediate valve junctions preparatory to putting the line back in operation during the night.

The most important factor was the utilization of trained personnel following a detailed plan, airplane patrol coupled with two-way radio communication, and testing equipment suitable for the job. Thus, by oil testing it is possible to postpone a test at any time due to inclement weather or for other reasons, without loss in line throughput.

To test a trunk line with water necessitates taking a section of the line out of operation while the oil is displaced with water and the test made. Such a procedure is time consuming and, obviously, no oil can be pumped through that section while the test is under way. In these days when refineries are running at or near full capacity, it is difficult, if not impossible, for a pipe line carrier to reduce its throughput to any marked degree.

Also, in making a water test, a greater number of employees must be assigned exclusively to the task because once the job is begun, it has to be finished without interruption. Other relative important duties must wait; furthermore, repair crews are required to work in excess of their regular schedule. The opportunity for accidents and inefficient work increases when crews are required to work overtime.

A third factor, and one that applied in Service's case, is the possibility that water would freeze in the line, and unduly retard the testing operations. The last factor applied in this instance be-

EXCLUSIVE

cause the 632-mile section tested extends from Oklahoma into Illinois, and winter weather is usually severe in Illinois and Missouri.

With no previous experience to serve as a guide, Service Pipe Line Company's maintenance staff devised a method whereby the tests were made with a minimum loss of pumping capacity.

Equipment Employed

A 6 by 6 duplex portable engine-driven oil pumping unit, equipped with size 2-in. pistons and liners, was set at the intermediate junction where it was conveniently connected to the lines by use of tapping nipples, so that oil could be withdrawn from one section of the line and pumped into another section, which was separated by block valves in the junction piping.

A 25-bbl portable truck tank was set and connected with the suction line of the portable pump so that an accurate gage could be taken to determine the amount of leakage after test pressure was attained.

The pump was also equipped with a modern relief valve, which is pressure controlled by a bottle of carbon dioxide gas.

When predetermined pressure was built up on the line the relief valve functioned to bypass the stream from the pump discharge line into the pump suction line. A pressure recording gage also was connected to the section of line under test to supplement pressure gages on both the pump discharge line and relief valve. With the pump taking suction from the portable tank, gages were taken at intervals of 15 min to check for leakage on the section of line under test pressure.

The Author

A. M. Hill, superintendent of line maintenance, Service Pipe Line Company, has technical supervision of pipe line construction and line maintenance, also procurement and maintenance of machinery used in pipe line repair work.

During 29 years with Service Pipe Line he has invented and developed pipe tapping machines, pipe line scrapers, pipe line repair equipment, special equipment and procedures for use in fabricating manifold piping systems by arc welding, and assisted with design of special truck bodies and associated equipment for pipe line maintenance. He has contributed to standardization of pipe line practices.

In 1936 Hill conceived the idea of the rubber scraper cup and had pilot models made in the company's shops, where they were tested and proved on special scrapers.

In 1939 he devised procedure for air swabbing pipe lines during construction period. This is now an established practice throughout the industry.

He represented the company in design of early pipe line pigs using rubber cups. Pipe line pigs are widely used throughout the pipe line industry for cleaning oil, gas, and products lines.

He designed and engineered development of the Hillco tapping machine, introduced in 1946. He has been engaged in machine work and welding for 35 years, and began pipelining in 1921 when he was employed on construction of the first major pipe line with welded joints, laid in Texas by Prairie Pipe Line Company, and fabricated some of the earlier manifold piping systems by oxy-acetylene welding.

A trial test was first run between Nelagoney Junction and Blake Station in Oklahoma. When the results there were found satisfactory, testing of the line by sections began. The second section to be tested was between Blake Station in Oklahoma, and Havana Junction in Kansas, and the following outlines the procedure employed, the same as used on subsequent sections of the line.

Crews were stationed at three strategic locations, outfitted with equipment to repair a leak or break. Their positions were such that one of the crews could get to a leak within a few minutes after it was spotted. A company patrol plane flew the line continuously while the test was under way to look for leaks or breaks and when one was found notified the nearest crew of its location by two-way radio. Sandbag messages were also used to report the location of leaks.

Pressure in the line was built up to 100 psi in excess of maximum operating pressure, and held for a period of 5 hr. After test pressure was attained, valves on the pump suction line were set to take suction from the 25-bbl portable storage tank, and the pumping unit operated intermittently to maintain the test pressure. The storage tank, having been filled with oil, was gaged at 15-min intervals to measure the volume of oil pumped into the line to replace leakage.

FIG. 2. At Blake Station George Nordt, chief station engineer, took pressure every 5 minutes. Pressure was held at 805 psi for 5 hr.

FIG. 3. At Havana Junction, on opposite end of section being tested, I. M. Barnett, Humbolt district superintendent, recorded pressures. Note gage reads same as that in Fig. 2.

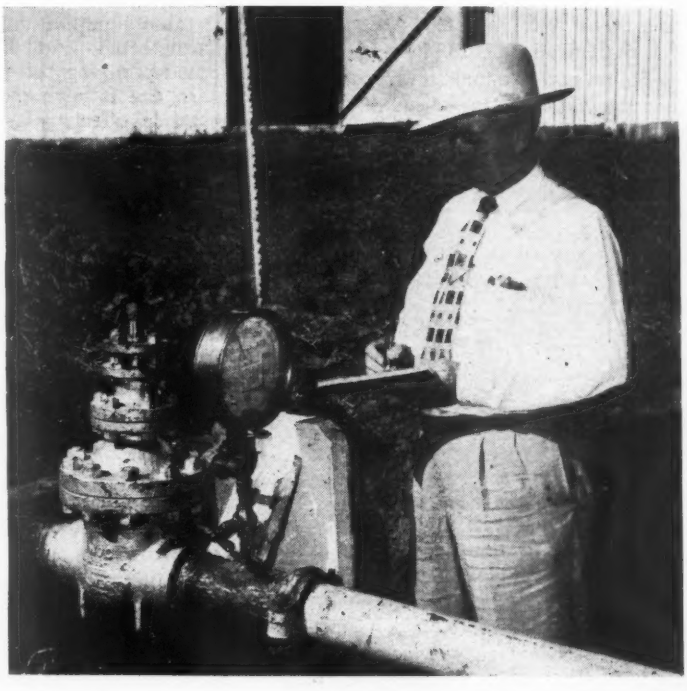


FIG. 4. Connection Foreman Paul Kebert reads the discharge pressure while Welder Barnard and Pipeliner Harold Wiltse look on. The four-wheeled pumping unit is pulled like a trailer by crew truck.

FIG. 6. While test was being made the line was patrolled by plane. When a leak was spotted the pilot radioed the information to nearest crew.

Preparatory to testing the Blake-Havana section of the line, the pumping unit, storage tank, and other equipment were set and connected with the line at Havana Junction, and the following morning the unit at Blake Station, which regularly pumped into the line, was shut down and head gates and other valves on this line were closed to prevent oil from going back into the manifold and storage tanks. Simultaneously, the valves at Havana Junction were closed and the pumping unit was immediately put in operation to apply test pressure on the line under test. Oil was taken from the line east of Havana Junction and pumped into the line west of the junction until the required test pressure was reached. The pumping unit operated 1 hr and 15 min to bring the pressure up to 805 psi, where it was held for 5 hr. The crew stood by watching pressure gages, while the plane patrolled the line.

FIG. 5. Jack Jones carefully gages the 25-bbl portable tank. It was used to keep the line being tested full of oil. A decided drop in its oil level would mean a line leak had developed.

With this section of line under test, Humboldt Station to the east continued to pump to Freeman on the system taking oil out of tankage. When the test was completed at the end of 5 hr, the portable pumping unit and tank were disconnected and Blake Station resumed pumping through the system.

On the following day testing equipment, in effect, was reversed to apply test pressure on the section of line east of Havana Junction. Oil was then pumped from the line west of Havana into that section of line eastward to Sycamore Junction. In this way, the testing equipment was used for both sections of line before being moved, and this method was followed throughout the testing operation.

After tests were completed on the Blake-Humboldt section, two crews were organized to test sections of the line in Missouri, and two crews in Illinois. This expedited completion of the work by carrying on testing operations in three states simultaneously; thus the man-hours spent by any one crew was not great, and the entire testing and line repair program was carried to completion without delaying other important work.

In January of this year increased oil movement through the system from Grafford to Houston necessitated testing about 80 miles of trunk lines between Mexia and Singleton, Texas. This system comprises 2 parallel 8-in. screw lines, and a single 10-in. combination screw and welded line between each of the stations. In testing these lines the same method was used with excellent results.

In conclusion, it may be pointed out that under certain conditions this method has many advantages over using water as a testing fluid; however, many of the older screw lines have pipe with very weak lapweld seams, and maximum test pressure must not exceed the ultimate working pressure for which the pipe was designed.

In modern lines that are constructed of seamless or electric welded pipe with welded joints, this method can be utilized more quickly and economically than by water testing, as the probability of bursting the pipe is unlikely.

With suitable equipment very small leaks can be detected, and the amount of leakage can be measured with a high degree of accuracy.

This method of pressure testing major trunk lines will enable the maintenance crews to test defective lines and carry on repair work when weather and ground conditions are favorable.

Obviously, this will effect substantial savings in maintenance costs of pipe lines by minimizing troublesome leaks, emergency line repairs, and subsequent damage to land traversed by the pipe line.

Experience has shown that lines that have been pressure tested operate with a minimum loss of shut-down time as a result of large leaks. ★ ★ ★

Auxiliary building.

P 620.

SAFETY IN GAS COMPRESSION

Engineers and designers have the duty of providing all possible safety measures and appliances—Here is described what equipment a safe compressor station should contain

STANLEY OWENS

The prime consideration in the design of all modern compressor stations is safety. With the advent of the piping natural gas into urban areas that have never used it, there has been some concern by these people of the relative safety of natural gas. This fear without basis has even extended to engineers and members of the legal profession in these regions in which natural gas is being pioneered. It is for the purpose of clearing up any misconceptions concerning the safety of natural gas that this article is written.

High Pressure Gas Piping

ALL high pressure gas piping in modern day compressor stations is designed and installed in accordance with the American Standards Association piping code. Section 2, Division 1, deals directly with gas and air piping. Transcontinental's compressor stations are de-

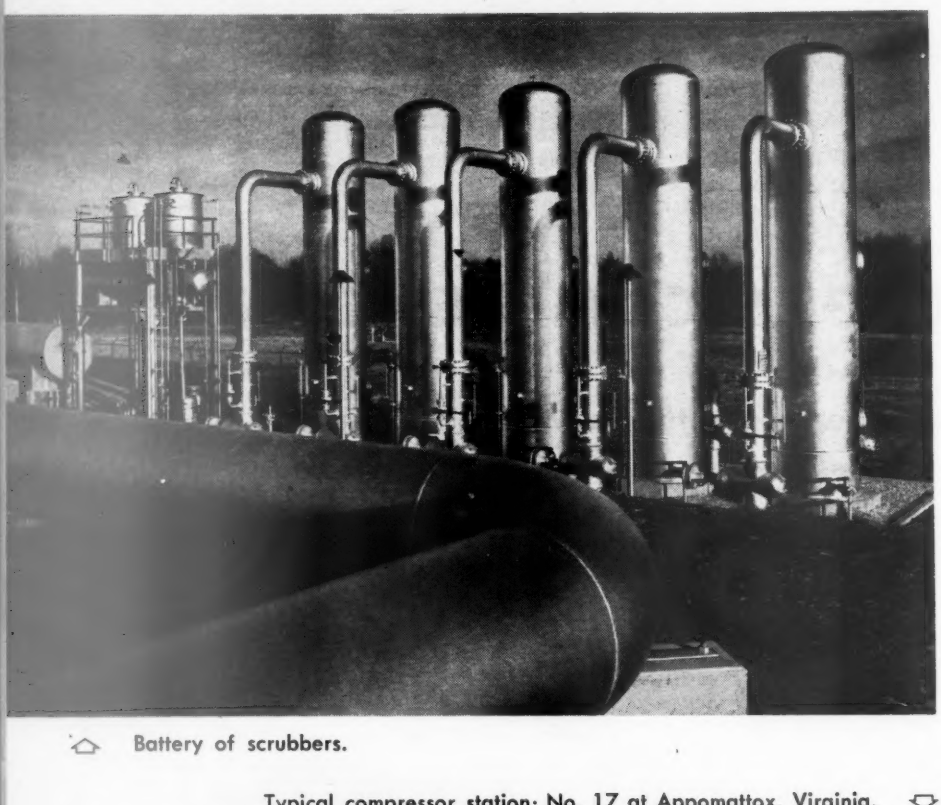
EXCLUSIVE

Safety steps over main line discharge header.

The Author

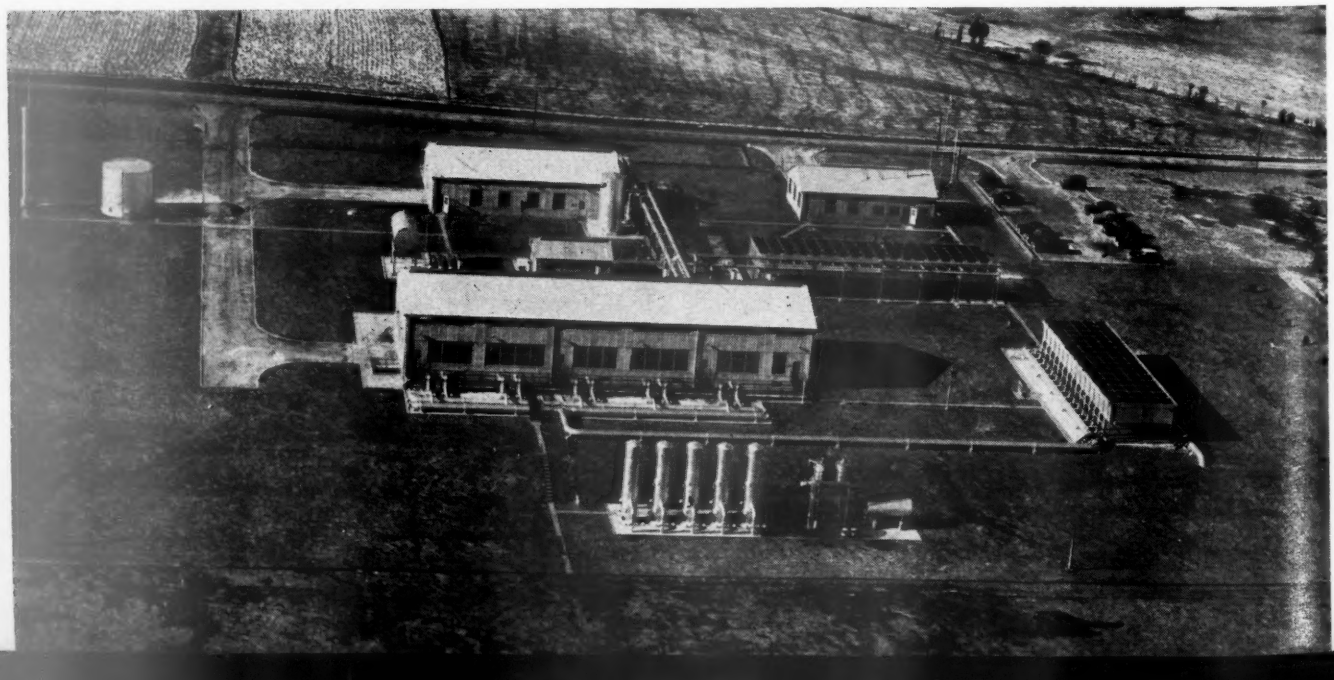
Stanley Owens, director of safety, Transcontinental Gas Pipe Line Corporation, holder of a BS degree in electrical engineering from Armour Institute of Technology, has had a wide experience in creating and maintaining safety organizations and insurance programs in public utilities and industrial plants. Shortly after Pearl Harbor he was appointed a member of the War Training Staff of the Illinois Institute of Technology. Subsequently, during World War II, he was regional security officer of the Facility Security Division of the Federal Government. He has had seven years' experience in casualty engineering, handling all types of casualty insurance engineering, setting up and maintaining plant safety organizations, etc. For three years he was resident and then chief engineer of heavy underground tunnel projects driven under air pressure. An interesting job was the demolishing of the 60-year old train shed of the La Salle Street railroad station in Chicago and erection of a new concrete structure. He was in charge of all safety operations on this project. He is a member of the AIEE, American Society of Safety Engineers, Houston Engineers Club, Veterans of Safety, Pipe Liners Club of Houston, Delta Tau Delta fraternity, and Natural Gas Transmission Safety Association.

PHOTOGRAPHS ARE BY ROBERT YARNALL RICHIE EXCEPT AS SHOWN.



Battery of scrubbers.

Typical compressor station; No. 17 at Appomattox, Virginia.



signed on this section of the ASA piping code. The code provides for an adequate safety factor in all high pressure gas and air piping, and takes into consideration temperature as well as pressure conditions. As this gas transmission line handles only sweet gas, there are no components of the gas stream that cause, or tend to cause, internal corrosion. External corrosion is guarded against by protective coatings and cathodic protection. All sub-surface pipe is installed with protective coatings. All high pressure gas piping and the compressor cylinders and bottles are hydrostatically tested to 1200 psig before being placed in operation.

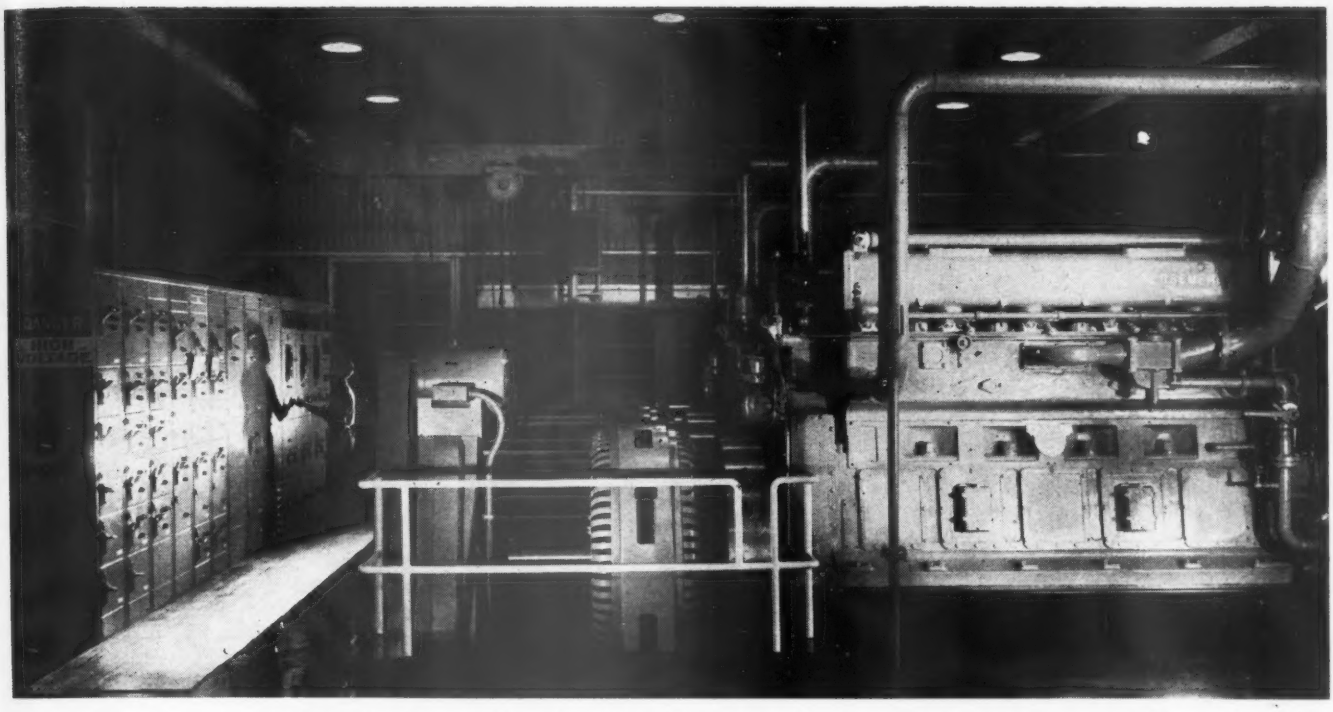
Utility and Low Pressure Piping

Utility and low pressure piping generally consist of lines for water, lubricating oil, free air, steam heating, and like services. In general, such lines are non-hazardous installations and no code requirements are applicable. The piping is designed for structural strength, which always far exceeds strength required for internal pressure. All materials handled by such lines are inflammable, such as lubricating oil and, of course, pipe lines handling this material are always designed to have adequate strength to contain the small internal pressures used, even in the presence of excessive external heat. Careful consideration is given to structural requirements of all overhead utility lines so that in case of failures of other parts of the installation, such structures will remain standing and will withstand excessive shock loads.

High Pressure Gas Valves

All high pressure piping is equipped with steel valves. The valve industry is governed by specifications and codes developed over many years of experience that apply to the material being handled. Transcontinental operates at 800 psig or less. Operating pressures ranging from 600 to 1000 psig require the installation of valves having a pressure rating of ASA 600 psig.

Two types of valves were used in the design of the Transcontinental compressor stations, one the lubricated plug valve, the other the full opening Venturi



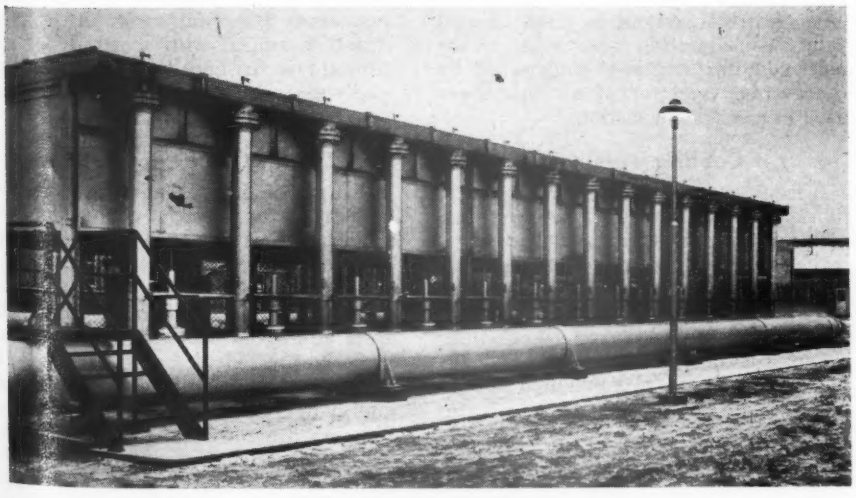
Inside layout of auxiliary building, showing switchboard on left and auxiliary electric generating equipment on right.

throat gate valve. Piping is designed for the installation of weld end valves, thus eliminating the use of flanges and the possibility of leaks at flange locations. The main line stations are designed with motor-operated side gate valves and main line block valves. The location of this installation is a minimum of 250 ft distant from the nearest hazardous operating area. Such areas usually are defined as those locations where operating men are in constant attendance, such as the main compressor building. The main line block valve and side gate valves' operators can be placed in operation (at all except the steam stations) by remote control at two points. The pressing of a button will automatically open or close the valves. As an added safety measure an emergency shut down switch is placed near the main entrance and exit of the plant.

Electrical System

The compressor station electrical system consists of equipment to generate electric power for lighting all plant facilities; operating water pumps and fans for cooling tower facilities, water circulating pumps, water well pumps, oil transfer pumps, starting air service, machine shop tools, valve operators, and other miscellaneous duties. In every electrical service special care and attention is given to safety design and the specifications of all safety appliances for such service.

Main building lighting fixtures on the operating floor where ventilation is exceptionally good are installed as vapor-tight fixtures; however, where basements are used and the ventilation at best is only fair, all lighting fixtures in this location are of the Class 1, Group D type, commonly called explosion-proof.



View of fin-fan cooling tower showing safety lighting fixtures.

All switches for operation of lights in main compressor buildings, whether in the basement or above the operating floor, are explosion-proof type. Such switches and the wiring and conduit installation are all made in accordance with Article 500 of the National Electric Code, 1947 edition. Installations that apply to this section of the code are known as explosion-proof installations and will meet requirements for installations in extremely hazardous areas. Where electric motors are installed in compressor buildings they are specified as explosion-proof. All starters and switches for such motors are also explosion-proof design. All conduit to the compressor building is installed with vapor seals to prevent gas-air mixtures from entering conduit lines.

Generating equipment is installed in an auxiliary building. Here the switchboard, transformers, electric control mechanism, air compressors, heating boilers, and other like equipment is housed.

All lighting in the auxiliary building is of the vapor tight design. Starters and switches are of the open type and conform to the NEMA No. 1 Code. This is permissible because the auxiliary building is a non-hazardous area, housing no high pressure gas facilities. The only gas lines in the auxiliary building are the low pressure fuel lines to the auxiliary engines and the heating boiler.

Particular attention is given to the safety features designed into the main switchboard. All bus bars, transformers, switches, circuit breakers, voltage regulators, and other necessary electrical equipment is housed in solid sheet steel cubicles, which prevent direct personal contact with any live equipment. An intricate system of lights and signals is included on the board for visual informa-

View inside compressor building showing flywheel fully enclosed and safety railing on overhead walkway.

tion to the operator. All high voltage, large heavy duty switches are specified as the draw out type. Such switches may be removed from the switchboard entirely when it is necessary to make repairs. The removing of the switch automatically disconnects it from the live circuit.

Electric distribution lines leave the switchboard from electric cable vault. The electric distribution lines are installed in conduit, either steel or orange berg type, encased in concrete and run underground to their destination. Cables leaving the main cable vault are vapor-sealed to prevent possibility of infiltration of ground gases or natural gas into the cable vault. All cables are installed on race ways and racks within the cable vault in order to prevent individual contact, which might result in abrasion or damage to the insulation and cause a hazard. Code requirements in all phases of the electrical work, and particularly for switchboard wiring, are carefully observed.

The fuel gas meter building is a hazardous location because it is subject to small amounts of gas seapage around regulator stems and vents from various control instruments. The meter building is particularly well ventilated and all lighting is installed with vapor tight fixtures; however, all switches are the explosion-proof type and the conduit entering and leaving the building is sealed.

Yard lighting is accomplished by the installation of commercial type floodlights. Such floodlights are installed in non-hazardous areas, usually in the perimeter of the plant area. Power supply to floodlights is run in conduit for mechanical protection when maintenance work is required in the yard area.

Wiring is installed underground to eliminate the hazard of lightning and, in a slight degree, to improve appearance. Particular attention is given to the physical completeness of electric installations. All receptacles and fittings are required to be installed with cover plates and gaskets. Receptacles in the meter and compressor building are required to be explosion-proof and installed complete with their cover plates and gaskets. The electrical system is given careful safety consideration because it is the most complex and least understood by the average operator of all equipment used in compressor stations.

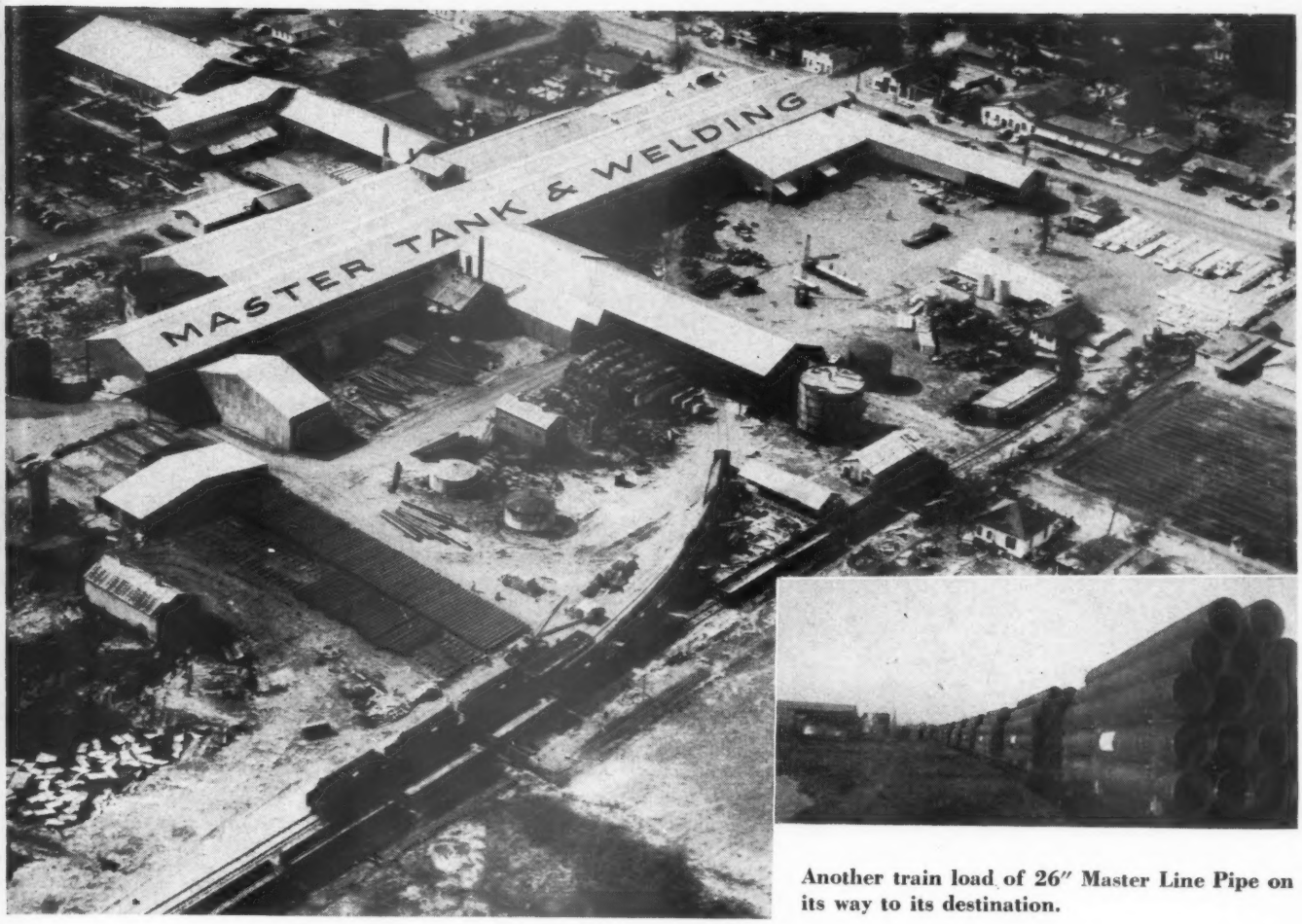
Cooling Facilities

It is necessary to cool the jacket water, lubricating oils, and high pressure gas. This is accomplished by two types of installation, one a cooling tower, the other the so-called air-cooling sections.

Transcontinental stations have used a combination of the two systems. Cooling towers are constructed of redwood and, as the name implies, is intended to cool large quantities of water. The structure, being wood, is situated at a minimum safe distance from operating hazardous areas. Such distance ranges from 50 ft upward, depending on the individual conditions existing at the specific location. Most modern cooling towers on compressor station service are designed on the induced draft principal. This requires the installation of large fans at the top of the tower. Water pumps are installed in the base of the tower for water circulation. The fans and pumps are electric motor operated. Fans are at the top level and are sometimes installed over gas cooling sections, and are specified as "tefc" (totally enclosed fan cooled). Water pumps in an open location where ventilation is ideal are specified as weather or drip-proof design. These are safety features that are considered necessary for the protection of personnel and equipment. A fire hydrant, equipped with a supply of approved type fire hose and nozzle in a specially designed cabinet, is located adjacent to the cooling tower.

Starting Air Compressors

All gas engines, whether used for the generation of electric current or the driving of gas compressors, are placed in operation through the use of compressed air. This requires the installation of air compressors that compress air from atmospheric pressure to 250 psig. The compressed air must be stored in large volumes in order to have sufficient energy to crank the engine. The air compressors use the latest safety improvements and such improvements are designed and included on the equipment as shipped from the factory.



Another train load of 26″ Master Line Pipe on its way to its destination.

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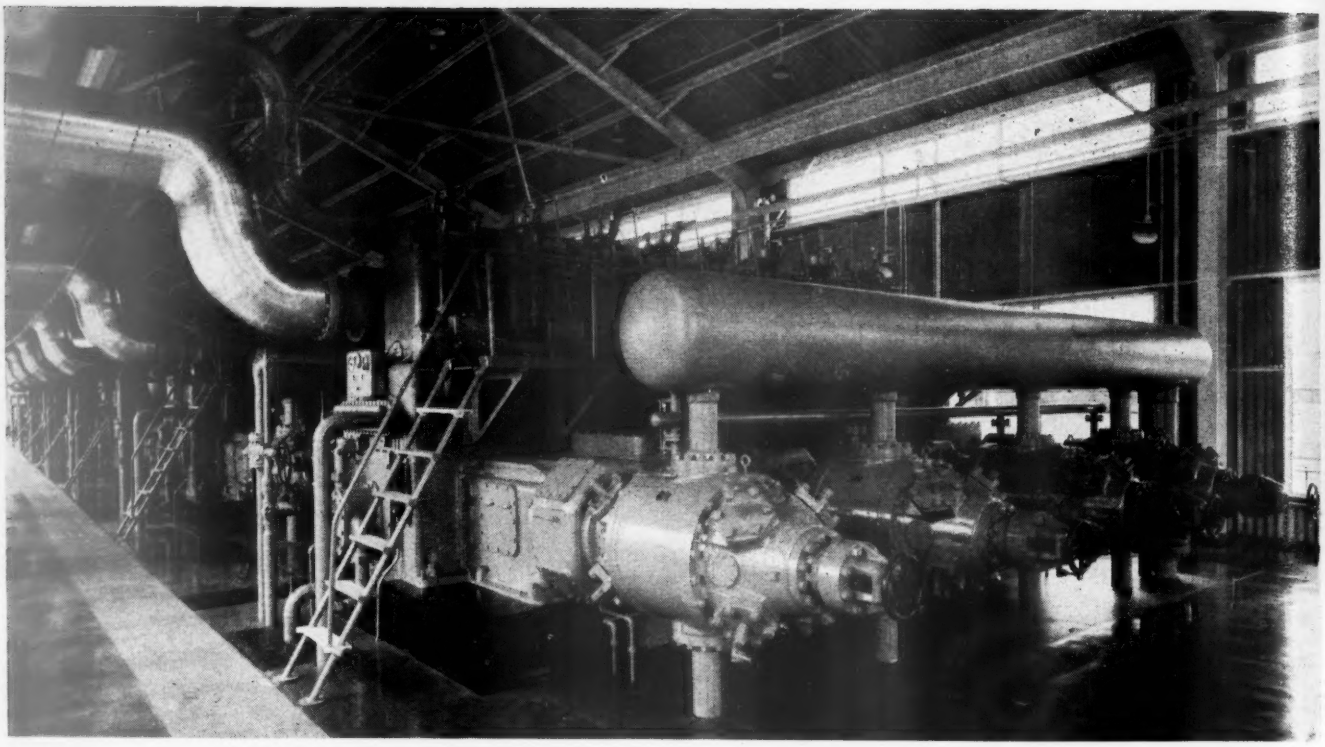


Overhead walkway for access to top of engine should have a safety railing as shown here. *(Photo courtesy Clark Bros.)*

Air compressors, as designed for compressor station work, consist of one electric motor operated unit and one gas engine operated unit. The gas engine unit is required in case the plant must be started from a cold start, that is, no electric current available and no air in the storage tanks. The electric motor unit is equipped with automatic starting and stopping between predetermined pressure points. This eliminates manual control and the possibility of ever exceeding the desired working pressure. The unit is also equipped with safety valves in case it comes into operation against a closed valve in discharge line.

In addition to built-in safety, operating personnel is trained in safe working practices and first aid, as shown by this group listening to a Transcontinental safety engineer. *(Photo by L. L. Nunley, Eunice, Louisiana.)*

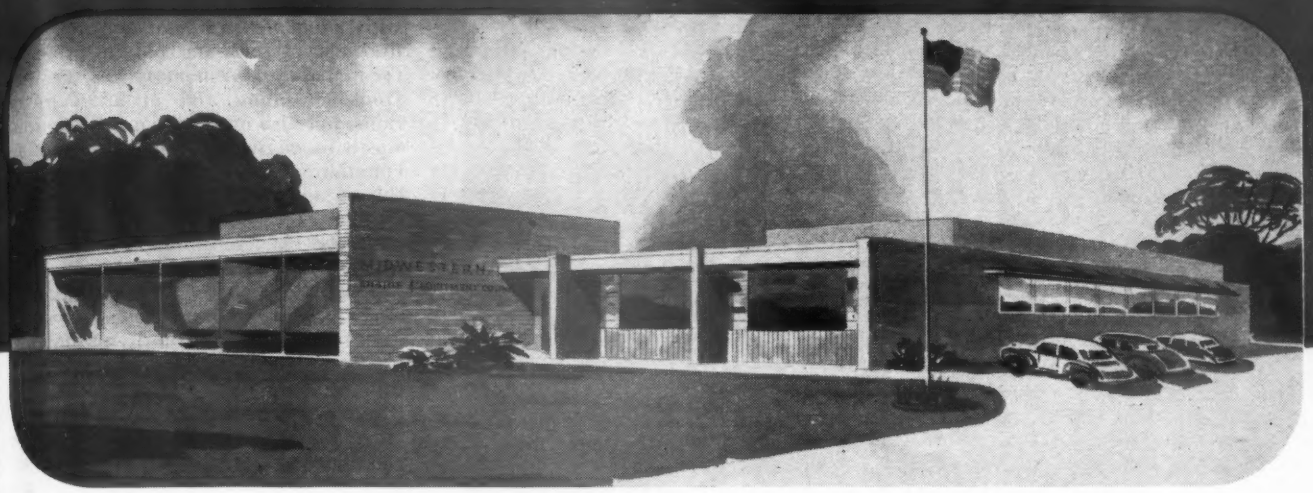
Gas Cleaners

It is highly desirable, both from a mechanical and safety viewpoint, that all gas be scrubbed or cleaned before entering the compressor. Transcontinental stations are equipped with Fish dust scrubbers. Dust scrubbers serve two purposes: (1) For cleaning the gas and (2) for collecting any slugs of liquid that may have entered the line during the construction, or condensed out of the gas due to unusual temperature and pressure conditions. Dust scrubbers are important to the safety design of the station. Should slugs of liquid enter the compressors, a serious failure would be caused in the cylinder and could well result in personnel injury or death, as well as extensive damage to the equipment. Should dust or dirt be permitted to enter the compressors with the gas stream, excessive wear is caused on the cylinder walls, piston, piston rings, piston rod, and piston rod packing.

Main Compressor Engines

Modern compressor station design employs the use of a well-developed reciprocating gas engine compressor unit. During the last four years tremendous improvement has been made in the design of centrifugal compressor equipment, which is increasing in use. Transcontinental has three such centrifugal compressor stations. Other large transmission lines have major installations of such equipment. For the purpose of this article, centrifugal compressor units will not be discussed because the subject of design and safety is too broad and special in scope to cover both it and reciprocating compressors in one article. Gas engines as used today are com-

DEDICATED *to Better Service for* THE PIPELINE INDUSTRY



The new home of the Midwestern Engine & Equipment Co., Inc.—to be under construction soon. This beautiful, practical building will be located at 4615 Sapulpa Rd., just a block east of the Tulsa junction point of U. S. Highway 66 and the new Oklahoma City-Tulsa Turnpike. The building, covering over 11,000 feet of floor space and with 12 acres of land for future expansion will house Midwestern administrative offices, warehouse stocks of the company's nationally known pipeline supplies, and will include a huge repair depot for heavy construction and contracting machinery.

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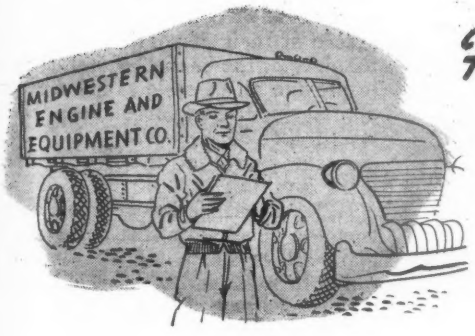

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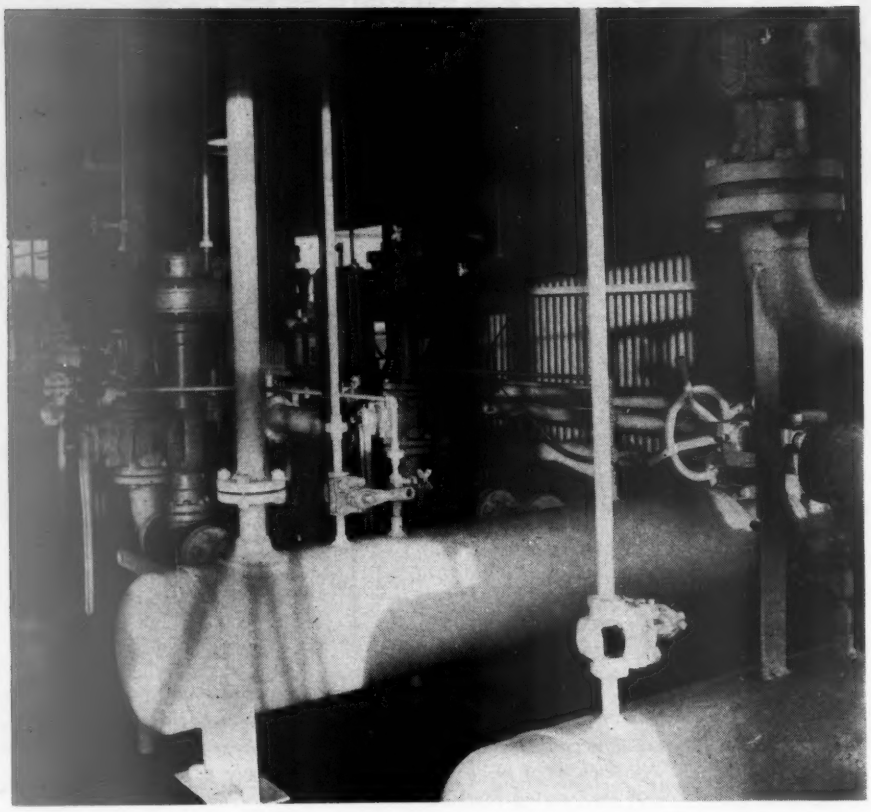

Inside of meter house.

pletely housed and no moving parts are exposed. Thus, mechanically it is a completely safe design with operating personnel entirely protected from moving parts when the engine is installed and operated.

The engines used in compressor station design are equipped with automatic shut down devices that are operated by low lubricating oil pressure, excessive high jacket water temperatures, over speed control, or failures resulting from any of these three principal sources.

In addition to the engine safety devices mentioned, manufacturers now supply with the engine an automatic fuel bleed system. This system is such that if the engine is shut down either automatically or manually, that the main fuel supply line is closed by an automatic diaphragm valve and all fuel between such shut-off valves and the engine cylinders is automatically bled to the atmosphere outside the building. This causes the engine to die of fuel starvation and assures the operator that no raw gas can enter any part of the engine during a maintenance operation.

This discussion has covered but a few of the safety features that are possible to install on gas engine compressor units. All are within the scope of the designing engineer who has played a large part in developing safety features provided by the manufacturers of principal equipment. The remaining safety features are innovations of the designing engineer working in cooperation with the operating organizations of the many operating companies.

Designed into the Transcontinental stations are automatic jacket water temperature coolers. This safety feature maintains automatic control of the cooling water temperature for the power cylinders, and the water entering the lube oil coolers. Such automatic systems eliminate the human element of control and its many errors and, at the same time, provide for manual control in case of failure of automatic control.

All exhaust manifolds are covered with insulation. This prevents the possibility of operating personnel falling on hot lines and receiving severe burns. Such design also prevents overheating of the building in summertime operation.

Safety Valves

High pressure gas and air piping are protected from over-pressuring by the installation of ASME Code approved safety valves. All compressor piping is designed for the installation of an accurately sized safety valve between the compressors and the compressor valve on the discharge header. Thus, if the engine is placed in operation with a closed discharge valve the safety valve will relieve any excess pressure.

As mentioned, all air compressors are similarly equipped with a safety valve. The air storage tanks are equipped with individual safety valves adequately sized to permit speedy relief of excess pressures. Such valves also will function in case of external heat applied to pressure storage vessels. Such an instance might be the case of a fire burning directly under or around an air storage tank.

Safety valves are installed on all gas dust scrubbers. These will operate in case of fire or in case of excessive shut-in pressure. The principal reason for such installation is in case of excessive heat resulting from adjacent or nearby fires.

Safety valves are installed on the scrubber oil charging tank, which is also a pressure vessel and is subject to the same dangers and hazards as outlined for the dust scrubbers.

Drainage System

Compressor stations must be equipped with adequate drainage systems. Such drainage systems not only provide for the disposal of waste materials resulting from scrubbing and cleaning operations, but also must take care of normal waste of engine oil, dust scrubber accumulations, boiler blow down, etc. All this is separate from the sanitary facilities.

Safety considerations are not ordinarily thought of as having major importance on such a simple drainage system. Experience has shown, however, that it is necessary carefully to plan and lay out such a system with safety features in mind.

Sump, crankcase, scrubber oil, and other liquid drainage are all carried to a classifier pit situated a safe distance from all hazardous areas and outside the plant fencing. The oils and other liquids are ignited and burned, or stored and hauled away periodically in accordance with local requirements.

General

The prime consideration of this article is the built-in safety features that result from experienced and adept design. From the above discussions it might be thought that the handling of gas is a hazardous operation. This is certainly *not the case*. The transmission of natural gas at 800 psig line pressures is a common and ordinary practice. Gas is handled and processed by other companies at pressures as high as 6000 psig. Such plants have many years of safe operation. In fact, many such plants have been operated during their entire existence without a single failure or accident. The handling of natural gas can be done safely and efficiently so long as it is given respect. Its operation only becomes dangerous when the personnel performing the operating duties become careless in the use of equipment and facilities placed at their disposal. It is therefore the duty of the engineers and designers to provide all possible safety measures, appliances, and appurtenances. The responsibility of the operator is to be on constant guard for the proper use of these facilities.

If these principles are carried out from the inception of the operation, the plant will be a safe and pleasant one in which to work and to have in the community as a part of local society.

Acknowledgment

The writer wishes to make grateful acknowledgment of the generous contribution made toward preparation of this article by R. D. Ricketts, vice president, Fish Engineering Corporation, Houston, Texas, designers and constructors of the compressor stations on the Transcontinental Gas Pipe Line Corporation system.

* * *

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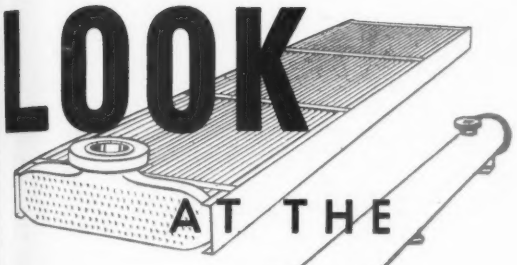

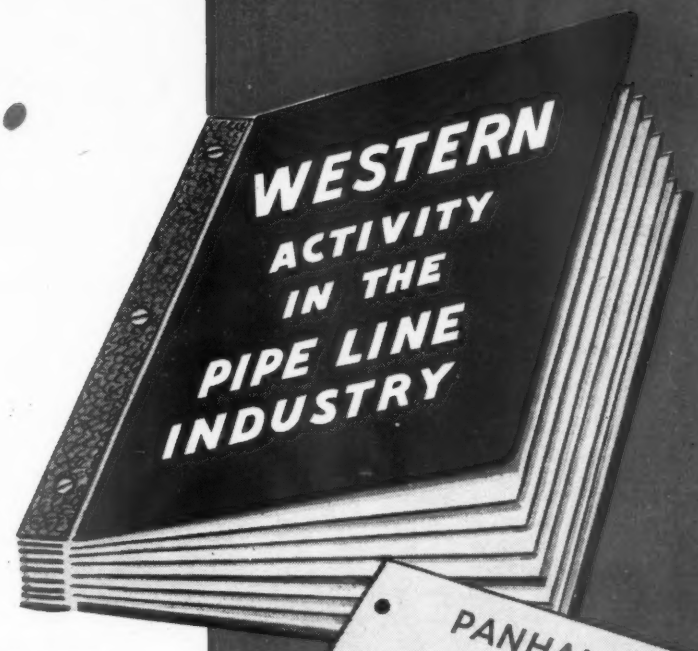

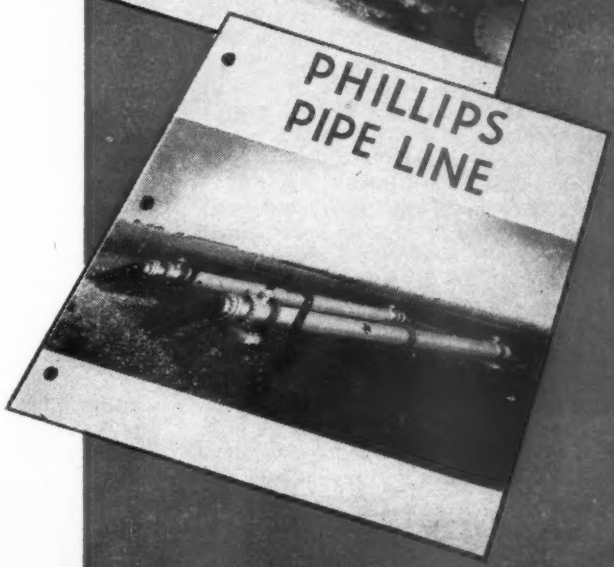

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Pipe Line Plugs in Construction, Maintenance

Dirt, water, ice, and all kinds of debris can be kept out of line and so eliminate a heavy cost later

By D. K. STEPHENS

SPECIFICATIONS for construction of pipe lines generally call for plugging or "night capping" the open end of a line with a water-tight plug when construction ends each day. Also, the ends of casings installed under highways and railroads ahead of the pipe gang are required to be plugged and remain plugged until the pipe is laid through them.

There are several excellent reasons for so specifying: (1) To keep children and men, who can't resist using the open end of a line for a target, from tossing into it every conceivable object they can get their hands on, (2) to keep snow and rain out, and (3) in case of a heavy rain, caving ditch, and loss of supports for the raised end of pipe the waterproof plug will keep the line dry even though it falls into a water-filled ditch.

All these reasons are important, though it is sometimes difficult to impress this fact on the minds of the contractor's men and company inspectors who are responsible for its being done and done properly. When the pipe is laid out and the gang knocks off for the day, there is a tendency to slap any kind of covering that is handy over the open end, such as a piece of canvas, gunnysack, tackweld sheet iron, or tin. These are not water-proof and a strong wind will blow the sack or canvas off. The consequences are not generally noticed until later when the line is cleaned and blown before putting in service. It is then the contractor or the company pays many times what it would have cost to close properly all open ends during construction. Objects such as large rocks, skids, tree limbs, steel bars, etc., will damage and sometimes destroy a wire brush cleaner. They will lodge in gate valves or bends and the line will have to be cut to remove them.

Water in the line in any quantity will come out ahead of the cleaning machine and generally remove the check joint from the end of the line, thus allowing the cleaning apparatus to hit the ground. As this apparatus is discharged from the line with considerable force, it is badly damaged upon direct contact with the ground.

Water that is allowed to enter a pipe line while under construction is seldom clean and the dirt settles out into the line, and, being wet for some time after the water is blown out, the dirt is hard to remove. Consequently, it dries after the line is in service and the operating department has it to contend with in engine and regulation valves.

The Author

D. K. Stephens is superintendent of pipe lines for Panhandle Eastern Pipe Line Company, and has his headquarters in Kansas City, Missouri. His first work with the company was in connection with construction operations. Subsequently he served as division superintendent until advancement to his present position in 1938.

In winter the water will freeze and removing the ice causes no end of trouble. A good plan is to do as many companies are now doing, i.e., when it is suspected that water is in a section of line, they insist that squeegees be run (several times if necessary) before a wire brush cleaning apparatus is used. This necessitates the cutting of the line ahead of the waters to install the squeegee. This is expensive and also delays the time of putting the line in service.

These consequences can all be avoided at a small fraction of the cost if water-tight plugs are used as specified.

Maintenance

It is frequently necessary to take a section of pipe line out of service to replace a bad piece of pipe or install a new connection, or a line may rupture and the ruptured joint have to be replaced.

On natural gas pipe lines when a section of line, usually 8 to 12 miles long, is taken out of service and "blown down" to atmospheric pressure for any of the above reasons, there is always a chance of some leakage getting past the gate valves at each end of the section. Even if there is no leakage, the line is full of gas, a certain amount of which will float out of the line at the point of opening. This makes hazardous working conditions, especially when any torch cutting or trimming is necessary, which is usually the case. Mudding-off the ends of the pipe, or waiting until all the gas in the line has been replaced with air, delays the work and is never positive protection against a flash. The following method is used by a number of companies to insure safety and to expedite the job. As soon as the joint of pipe to be replaced is removed from the line, an internal plug is inserted in each end of the pipe and left in the ditch and tightened in place. A nipple long enough to extend from the plug to the end of the pipe is screwed into the vent tap in the face of the plug. An ell and longer piece of pipe is then used to vent the gas to the air several feet above the ground level. Gas coming from the vent is ignited. All cutting and trimming can then be completed before the plugs are removed to replace the new joint of pipe.

Sometimes when replacing a joint that has ruptured while in service, it is necessary to cut several feet off the ends of the pipe left in the ditch. In that case, the plugs can be shoved into the line as far as necessary to get them past the location of the cut before they are tightened in place. For this reason internal plugs are more adaptable for general use than plugs that fit over the outside of the pipe. Also, internal plugs are less likely to be disturbed or knocked off the end than the external kind.

Caution should be taken to avoid flanging-up a line and forgetting to remove the plug or plugs. A small chain fastened to the plug and long enough to hang outside the end of the pipe is a good reminder.

Plugs or "night caps" of the type mentioned here are not designed to withstand any more pressure than is required by a 10-ft ditch full of water, or that of a leaking valve with the line vented at a blow-off valve and also at the plug if necessary. Even in large size lines this latter pressure is very small, seldom greater than a fraction of a pound.

Our experience indicates that every contractor should have at least a dozen plugs of the proper size available for each pipe line spread, and each pipe line maintenance crew should be equipped with no less than two plugs of each size to fit each size pipe in the lines in their respective districts. ★ ★ ★

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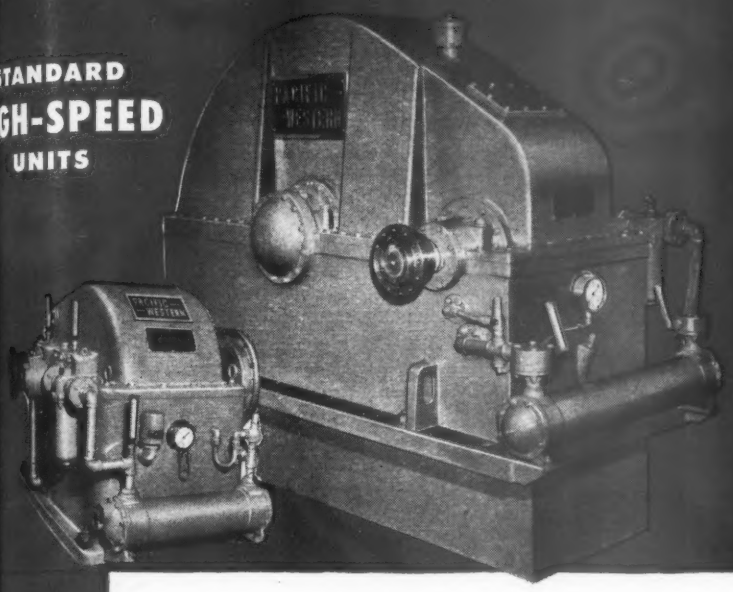

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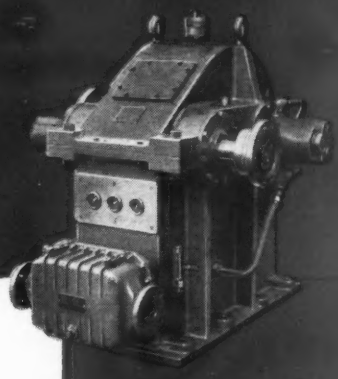

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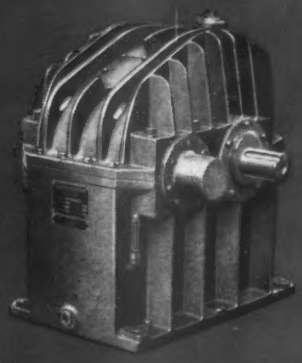

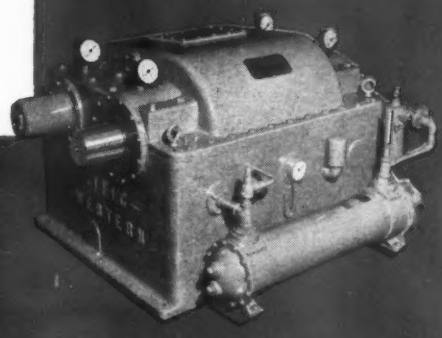

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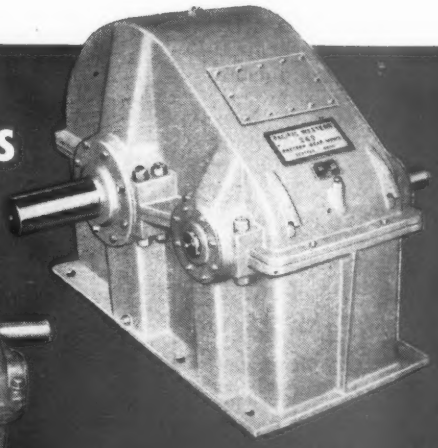

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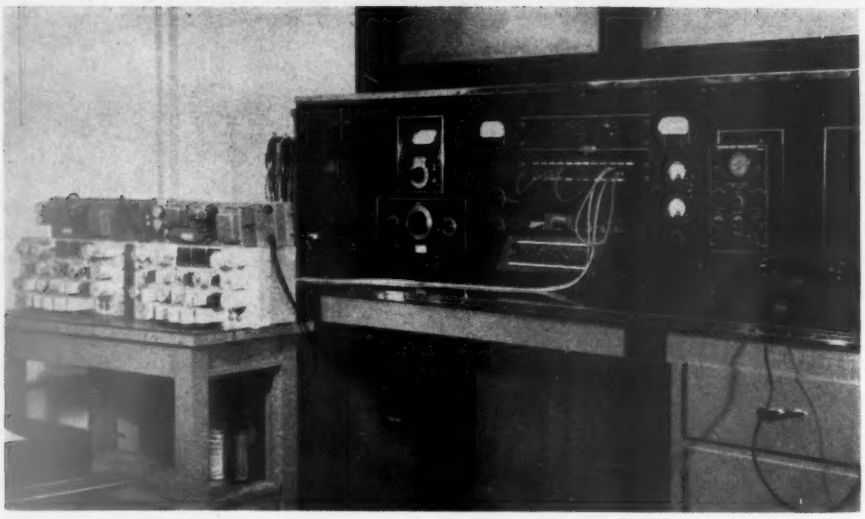

An interior view of Sinclair's communications shop at Independence, Kansas.

Control of Unattended Gathering Stations

Apparatus devised in company shop enables dispatcher to handle operations over telephone circuit

L. E. COOK AND S. M. HAMMER

MOST communications equipment manufactured today is styled and designed for local exchange and common carrier communication company use. As such, it is not always suited to pipe line use where multiple party lines are set up by telephones bridged across a physical circuit at convenient points using magneto operation. It is, therefore, necessary to construct the required apparatus, or to modify apparatus that has been purchased to meet the individual company circuit requirements.

An interesting example of this was experienced during 1951. It was desired to set up a system whereby the oil dispatcher would have access to information from, and limited control over, small unattended crude oil gathering stations. This would require a d-c path or the presence of tones of various frequencies on the line if various types of apparatus available on the general market were used. It was not desired to do this because the circuit was required for dispatching as much as possible and we did not wish to load the line, which had many side legs with a number of coils or composite sets. Also, it was necessary to use equipment not requiring a-c power at the gathering station in order to have use of this service during power interruptions. It was also more convenient to the dispatcher if he had no extra equipment to watch or operate, so that he could monitor and control using coded 20-cycle rings for which he was equipped in his regular telephone position.

This need was met in the form of equipment that was designed and constructed in the Independence communications shop. Briefly, the equipment enables the dispatcher to ring-in the desired station, receive a reverting buzz-back signal to identify that station, and to hear a group of chime notes indicating that the power line is on and at the same time hear whether the discharge pump motor is running.

A small time motor shuts down the monitor equipment at the end of about one minute. During that monitor cycle, or a similar one, a second but different code ring will start up the motor, if desired. Likewise, a third code ring made during the cycle will shut down the motor if so desired. In some cases instead of starting the motor, as where line pressure or hand start switch will not permit, the second code ring may be used to connect a nearby residence phone across the main telephone line and the occupant rung by the dispatcher for instructions. A release button on the equipment is pressed to remove house phone from main line before leaving the station.

The device, which interprets the coded ringing signals on the line and converts pre-established codes into functions, is a secode selector. The required longer pulse necessary to its proper operation and the necessity of ringing both the station code and that for either a start or stop function that must culminate within the one minute period precludes the possibility of undesired start or stop functions being performed accidentally. The selector, function-relays, and time motor operate from current supplied by a storage battery kept charged by a floating trickle charge.

During 1951, ten of these devices were fabricated in the communications shop, three of which were installed at Wolf, Pharo, and Brown stations. Previously, trial models were installed at Springer and Post Oak stations.

Experiences such as the above have proved to us that a communications shop, suitably equipped with proper tools and personnel for fabrication and modification of communications equipment, can be a very desirable operation.

* * *

EXCLUSIVE

The Authors

L. E. Cook

S. M. Hammer

L. E. Cook, superintendent of communications department for Sinclair Pipe Line Company, joined Sinclair in 1948. His background and experience in the communications field was obtained through his service with the American Telephone and Telegraph Company from 1940 to 1948. His present activities include director of Petroleum Industry Electrical Association, president of Tulsa PIEA Club, and member of API Radio Committee.

S. M. Hammer, electronics shop foreman for Sinclair Pipe Line, began his experience in the communication field after graduating from Lane Technical High School in his native city, Chicago. He joined Swedish American Telephone Manufacturing Company, and in 1918 Kellogg Switchboard and Supply Company. He was employed to wire and install central office exchanges, after which he worked in the experimental and radio laboratories of that company where he experimented with radio receiver design and carrier frequency application to exchange cable systems.

In 1932 Hammer joined Sinclair to design and produce an impulse type tank gage and later redesigned an existing selsyn type water tank gage for application to oil tank gaging. In recent years he has designed and supervised the construction of several wire chief test boards and a remote monitoring and control device used with unattended pump stations.

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Advances in Gas Dehydration Processes

Widespread transmission of natural gas requires close control of residual water vapor content

LAURANCE S. REID

WIDESPREAD transmission of natural gas from the Southwest to virtually all parts of the continental United States requires close control of the residual water vapor content of the gas to assure optimum performance of transmission and distribution facilities. Gas dehydration processes and techniques have been developed at a rapid pace to meet the demands of the gas industry, which has grown at a phenomenal rate since the close of World War II.

Gas dehydration was practiced for many years on a very limited scale, employing processes whose performance would be considered rather mediocre when compared to present-day results. War-time demand for natural gas resulted in the use of increased pressures in existing pipe lines, and new higher-pressure transmission facilities were built to supply gas to colder climates. These developments focused attention on gas dehydration as operational difficulties caused by gas hydrate formation are accentuated by higher pressures and are further aggravated by lower temperatures. In projecting new transmission lines it was obvious that the water vapor content of the gas would have to be controlled at a low level at all times to prevent service interruptions. For economic reasons, early practice was to gather wet gas in quantity and dehydrate it in large, centrally located plants prior to turning it into transmission systems.

Since 1946, the unprecedented growth of the gas industry has required production of gas from many wells completed in remote and virtually inaccessible locations via high pressure gathering systems, and this development has presented many new problems and unusual applications to the designers and fabricators of gas dehydration processes. This challenge has been met by intensive development of new and improved processes capable of handling the production from one, or from a number of wells at any desired working pressure, dehydrating the gas efficiently and economically with minimum attendance. Where applicable, two of the newer processes also effect a substantial increase in liquid hydrocarbon recovery, which greatly enhances the economics of dehydration.

Most gas pipe line companies have followed the precedent established by the Tennessee Gas Transmission Company in specifying a maximum permissible water vapor content of 7 lb per 1,000,000 cu ft of gas, measured at 14.7 psia and 60 F, but an average moisture content well below this level is sought at all times. The water vapor content of a gas is usually determined by observing the water dew point at system pressure and interpreting the results obtained in terms of pounds of water vapor per million standard cubic feet by means of a graphical correlation such as that shown in Fig. 1[2]. Performance of a gas dehydration process is usually determined by dew point measurement of the inlet and outlet gas streams. If the process operates at essentially constant pressure, performance is often evaluated in terms of "dew point depression"; i.e., the inlet dew point minus the outlet dew point in degrees Fehrenheit.

In addition to a number of significant improvements that have been applied to existing processes, one new process has been placed in commercial operation and has proved successful to a marked degree during the past year. Several recent advances seem worthy of discussion.

The Author

Laurance S. Reid, chairman of the School of Natural Gas Engineering, University of Oklahoma, attended Rice Institute and received a BS in chemical engineering from Iowa State College in 1931. After several years experience in the production and refining of petroleum, he completed requirements for the MS degree in chemical engineering at Oklahoma.

Following his graduate studies he was associated with Phillips Petroleum Company engaged in research on secondary oil recovery methods and was later associated with Black, Sivalls and Bryson, Inc., as development engineer. From 1940 to 1943, Reid served as associate professor; from 1943 to 1945, he was with the Southern Natural Gas Company as assistant chief engineer; in 1945, he returned to the University of Oklahoma as professor of chemical engineering.

Absorption Processes

Simple absorption processes employing diethylene glycol as the absorbent have been used to dehydrate natural gas for more than a decade. Properly operated, these processes produce a dew point depression of 45-50 F, which, under carefully controlled pressures and inlet temperatures, is usually sufficient to produce specification gas. Concentration of the diethylene glycol-water solution circulated in these processes usually ranges from 95 to 96.5 per cent by weight glycol, maintained by atmospheric distillation at a reboiler temperature of approximately 325 F. More recently, several dehydration plants have been installed in which the solution is concentrated to a higher degree by means of vacuum distillation and dew point depressions are reported to range as high as 90 F.

During the last three years, simplified absorption processes employing highly concentrated solutions of triethylene glycol have proved to be very effective means for gas dehydration. A flow diagram of this process is shown in Fig. 2 and two typical installations, one small and one large, are shown in Figs. 3 and 4, respectively. Triethylene glycol-water solutions may be concentrated to 99 plus per cent by weight glycol by atmospheric distillation at a reboiler temperature of 390-400 F. These concentrated solutions consistently produce dew point depressions ranging from 75 to 95 F.

Sufficient field data are now available to show that, when circulated at equal rates and concentrations, triethylene glycol is slightly more effective than diethylene glycol. It is rarely possible, however, to concentrate diethylene glycol in excess of 96.5 per cent by distillation at atmospheric pressure for any extended period of time because of a tendency for this glycol to decompose at temperatures exceeding 325 F. So triethylene glycol enjoys a distinct advantage in the fact that it can be concentrated to a very high degree by simple atmospheric distillation, whereas expensive vacuum

EXCLUSIVE

distillation is necessary to accomplish the same result with diethylene glycol. The benefits to be realized from maintaining very high glycol concentrations may be better appreciated by consideration of the rough approximation that the dew point depression may be extended 40 F by increasing the glycol concentration from 95 to 99 per cent by weight.

Recent investigations by Townsend[5] show that concentrated solutions of triethylene glycol effectively dehydrate gas in the temperature range 70-90 F and pressures as high as 3000 psig, while Politziner et al[3] report that triethylene glycol vapor losses at 3000 psig and atmospheric temperature are small and well within the limits of economic operation, and that they are substantially smaller than losses sustained from use of diethylene glycol.

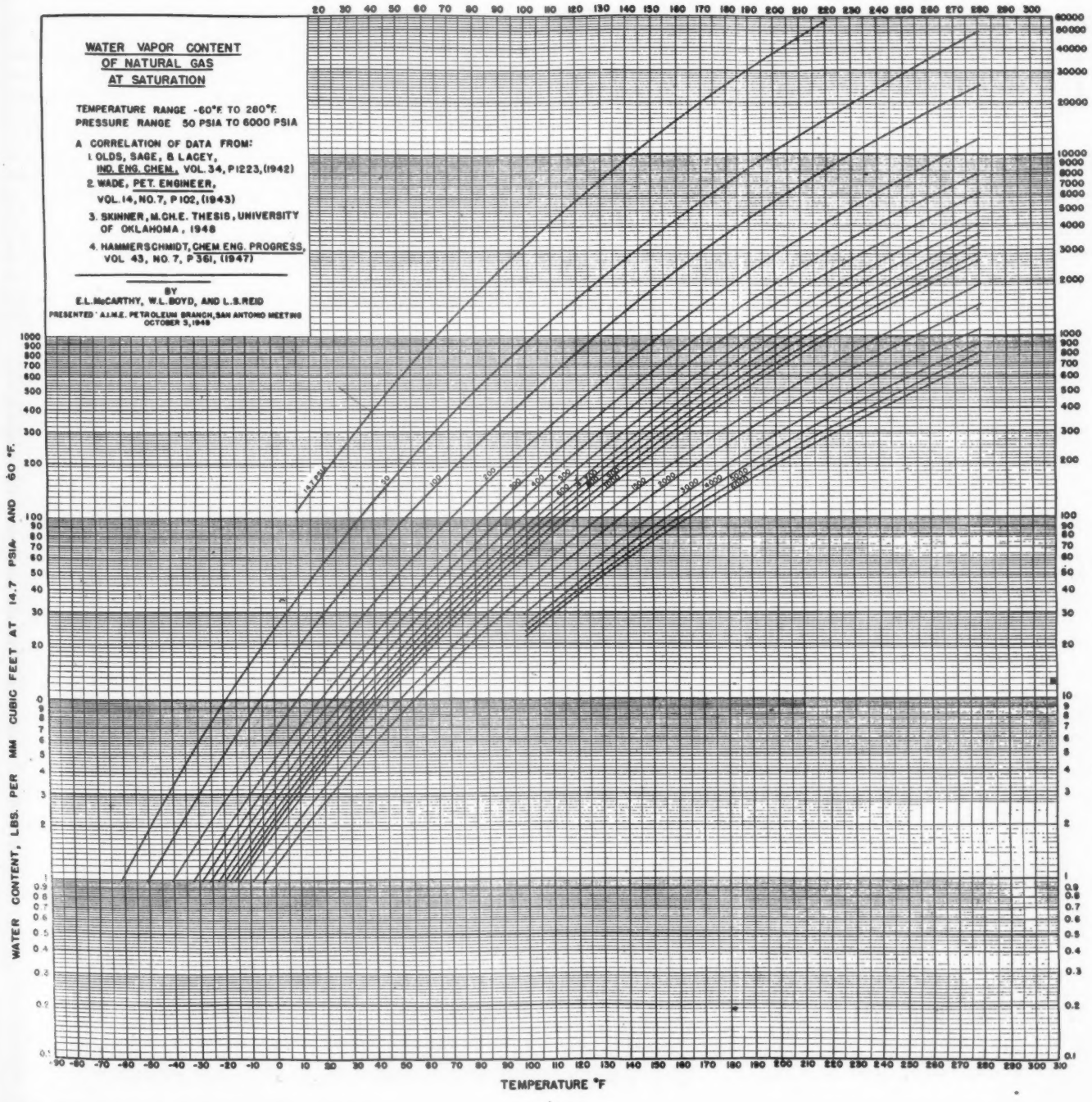
It is essential to protect glycol absorbers with inlet scrubbers to remove crude oil, absorber oil, lubricants, and brine from the gas prior to the glycol contact. Failure to do so may cause foaming and resultant glycol loss, contamination of the solution, and corrosion and ultimate failure of the reboiler. Glycol absorption, like all other dehydration processes, is severely penalized by high inlet gas temperatures. This temperature should never exceed 100 F and, in general, the lower the absorber temperature, the better will be the performance of the process.

Glycol absorption is the least expensive and the most flexible of the various gas dehydration processes available at present. It is simple, compact, completely salvageable, and well adapted to automatic operation.

Adsorption Processes

Adsorption dryers have been used for dehydration of natural gas for more than a decade and it is believed that earlier installations followed quite closely designs used for drying air and other industrial gases. Silica gel, one of the most efficient desiccants known for air drying, was found to be unsuited for use with natural gas because of its affinity for heavier hydrocarbons and resultant rapid loss of capacity. Activated bauxite and purified activated alumina were better suited to this service and

FIG. 1. Water vapor content of natural gas at saturation.


WATER VAPOR CONTENT
OF NATURAL GAS
AT SATURATION
TEMPERATURE RANGE -60°F TO 280°F.
PRESSURE RANGE 50 PSIA TO 6000 PSIA
A CORRELATION OF DATA FROM:
1. OLDS, SAGE, & LACEY, IND. ENG. CHEM., VOL. 34, P1223, (1942)
2. WADE, PET. ENGINEER, VOL. 14, NO. 7, P 102, (1943)
3. SKINNER, M.CH.E. THESIS, UNIVERSITY OF OKLAHOMA, 1948
4. HAMMERSCHMIDT, CHEM ENG. PROGRESS, VOL 43, NO. 7, P 361, (1947)
BY
E.L. McCARTHY, W.L. BOYD, AND L.S. REID
PRESENTED A.I.M.E. PETROLEUM BRANCH, SAN ANTONIO MEETING OCTOBER 3, 1949
WATER CONTENT, LBS. PER MM CUBIC FEET AT 14.7 PSIA AND 60 °F.
TEMPERATURE °F

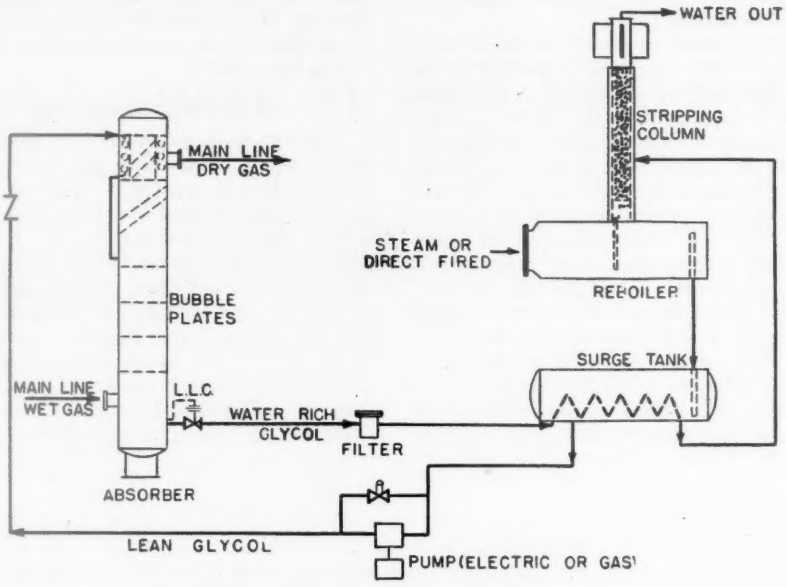


FIG. 2. Flow diagram of a simple absorption process employing triethylene glycol.

have been widely used up to the present time, despite notable progress in the development of newer gel desiccants in more recent years.[6]

Since its inception, the adsorption process has been of cyclic design in order to process gas continuously; i.e., each unit consists of two sorbers, one of which is reactivating and the other is in drying service. Reactivation is accomplished by passing a relatively small stream of hot gas, under system pressure, through the saturated sorber where it desorbs moisture and accumulated hydrocarbon liquids. This gas is then cooled, its condensate removed, and the gas returned to and mixed with the main gas stream passing to the drying sorber so that no gas is vented.

There have been some notable improvements in adsorption process design in recent years. Considerable attention has been directed to desiccant attrition or dusting, prevention of gas channeling through the desiccant, and reduction of pressure drop across the unit which, in some instances, range from 50 to 150 psi. These difficulties are commonly found in earlier units whose sorbers were vertically disposed so that the entire gas stream passed downward through the entire sorbent mass, and where reactivation heat was supplied by 250-300-lb saturated steam, which is barely adequate for reactivation under ideal conditions.

Fig. 5 shows an improved adsorption process in diagrammatic form and a typical installation is shown in Fig. 6. This design has overcome the difficulties mentioned above by (1) dividing the main gas stream into two or more separate streams that flow in parallel through desiccant contained in separate compartments of a horizontally disposed sorber, (2) actuating the sorber switch valves so that they operate in proper sequence to prevent momentary pressure surges from lifting and damaging the desiccant when the cycle is changed, and (3) by providing adequate reactivation heat by means of a salt bath heater capable of bringing reactivation gas to the sorber at temperatures ranging from 400 to 700 F, as desired.

This design embodies a number of unique operating features. For example, it is not uncommon to operate an adsorption unit at such a low flow rate that a substantial part of the total gas flow is required for reactivation, resulting in excessive outlet gas temperatures. When such a condition exists at a dehydrator of the new type described above, one or more compartments of the sorber may be shut in and taken out of service. A correspondingly smaller quantity of reactivation gas is then required for the active compartments, restoring a near-normal heat balance. Pressure drop through the desiccant beds of a horizontal compartmented adsorber ranges from 1 to 5 psi so that the total pressure drop across the unit is the sum of this differential plus that pressure drop required to pass the reactivation gas to and from the heater, as the system is connected in series. Total pressure drop usually ranges from 10 to 20 psi.

The problem of removing heavy oil mists from inlet gas, or from the desiccant, still defies economic solution. In this instance, the usually satisfactory performance of oil and gas separators is not adequate. Even at an entrainment rate of 0.1 gal per 1,000,000 std cu ft of gas passed, enough heavy oil collects within and on desiccant granules to destroy their sorptive capacity and, where this condition is severe, desiccant replacements are frequent and costly. Lubricating oil from compressor stations, absorber oil from gasoline plants, and, to a lessor extent, heavy hydrocarbon fractions in condensate-bearing gas are the principal offenders and all effective-

FIG. 3. A small triethylene glycol absorption process situated in South Texas.

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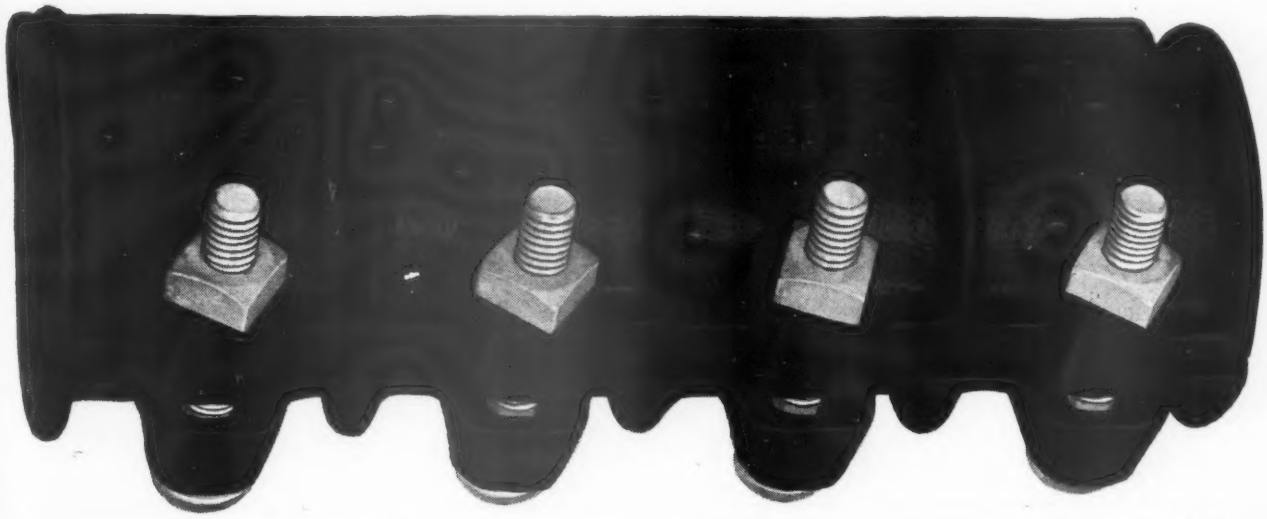

FIG. 4. A large triethylene glycol absorption process in Northern Louisiana.

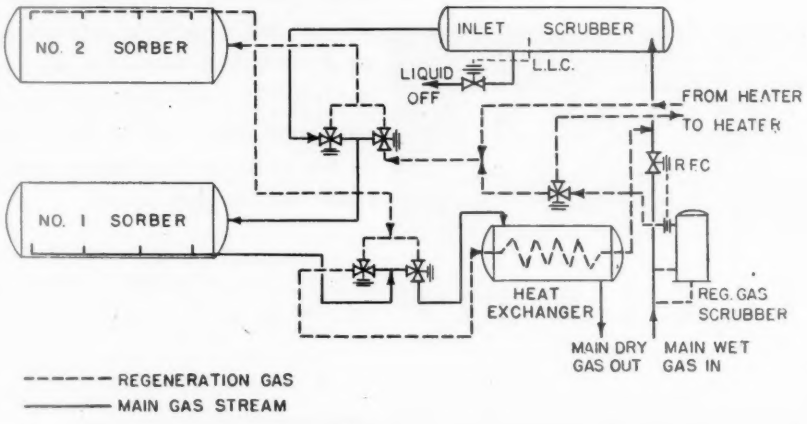

FIG. 5. Flow diagram of an adsorption process for gas dehydration.

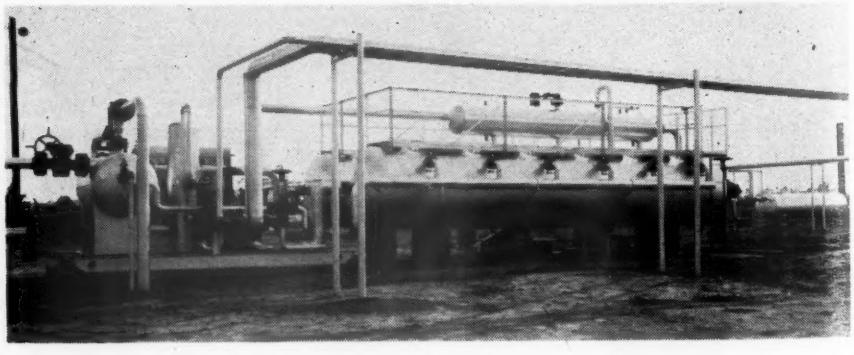

FIG. 6. Adsorption process with horizontal compartmented sorbers and salt bath heater for reactivation gas.

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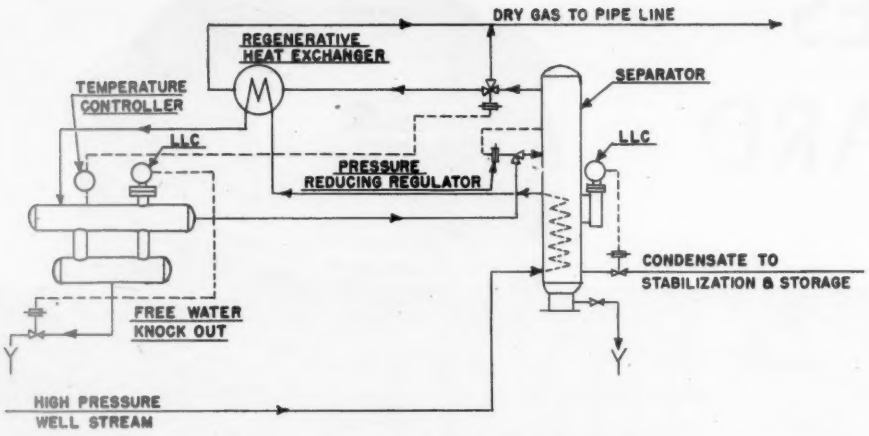


FIG. 7. Flow diagram of low-temperature separation process.

ly resist removal by the usual reactivation procedure. The problem has been solved, at considerable expense, by passing inlet gas through spent desiccant in a high pressure pre-contactor vessel where the oil mist adheres to the large wetted surface of the mass. Several methods have been proposed for restoring sorptive capacity by removing these oils from desiccants but this development apparently remains in the "paper stage."

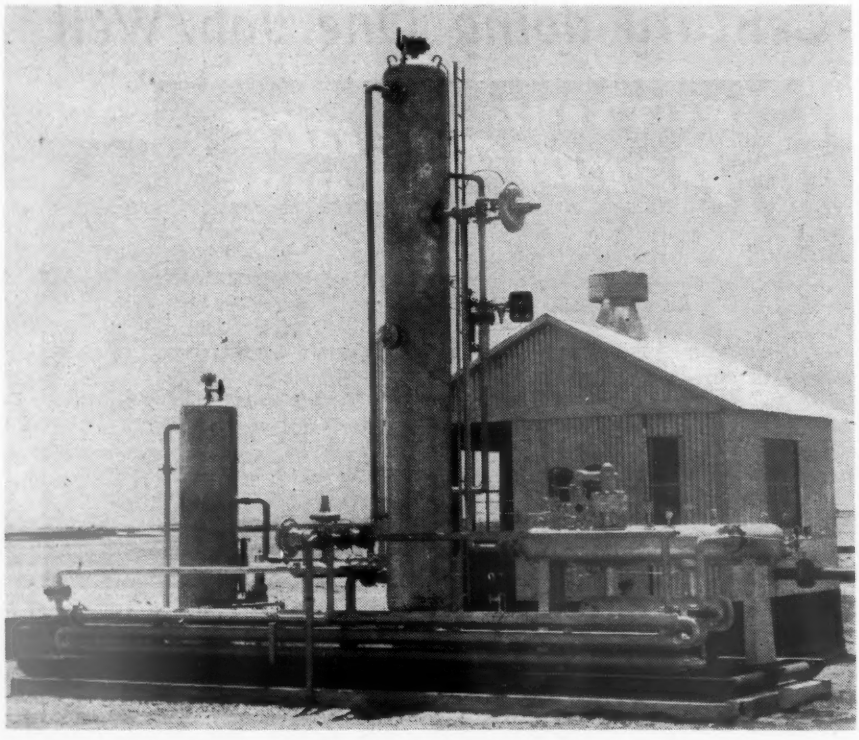
Low Temperature Separation Process

Dehydration by means of the low-temperature separation process is relatively new. It has enjoyed rapid acceptance by the industry where large pressure differentials between wellhead and gathering system prevail, particularly since recovery of liquid hydrocarbons is substantially increased by the low-temperature operation. In general, it may be stated that a 1200-psi differential must be available to enable this process to meet pipe line moisture specifications. The process will not be competely effective throughout the productive life of a gas well or field where pressures decline and, ultimately, it will have to be replaced by other means for dehydration.

There are numerous modifications of the low-temperature separation process available for unusual applications, but the fundamentals of the process are shown by the flow diagram, Fig. 7. A typical commercial installation is shown in Fig. 8. Hot high pressure gas from the well is passed through a coil in the base of the low-temperature separator where it warms the separated liquids, decomposes the gas hydrates, and is moderately cooled itself. Emerging from the coil the well stream passes to a heat exchanger where cold gas reduces its temperature to a point just above the hydrate temperature at wellhead pressure. From the heat exchanger, the well stream passes to a free-water knockout where the liquid phases separate. Free water is discharged from the system while the liquid hydrocarbon is recombined with the gas and the mixture expanded to gathering system pressure via a choke set in the inlet to the low-temperature separator. Additional condensate and hydrate are formed by this expansion and these drop to the bottom of the vessel where the hydrates are decomposed, forming a free water phase. Cold dehydrated gas is discharged from the top of the separator and part of the stream is routed through the heat exchanger to cool the incoming well stream by means of a thermostat-controlled three-way valve. Liquids are discharged from the separator to stabilization and storage.

This process has a number of attractive features. Despite the fact that it is substantially more costly than the glycol absorption process, a 10 to 25 per cent increase in liquid hydrocarbon recovery often makes it a highly attractive investment. Where wellhead temperatures are sufficiently high, no additional heat is required. This decreases investment and operating costs and removes a potential fire hazard. The units are usually assembled on skids and piped ready for use. Units assembled from standard oil field equipment can be dismantled and used in standard field operations if desired, enhancing the salvage value.

FIG. 8. Skid-mounted low-temperature separation unit.



Glycol Injection Process

The fundamental principles of the glycol injection process have been known for 12 or 15 years, but commercial application is the most recent development in the field of gas dehydration. A flow diagram of the process is shown in Fig. 9 and a large commercial installation is shown in Fig. 10.

The basic principle of the process is to inhibit gas hydrate formation by mixing into the gas stream small quantities of glycol-water solution, to separate the gas and liquids at very low temperatures, to separate the glycol from the condensate, and to reconcentrate and recirculate the former to comprise a continuous process. A detailed description and discussion of the process has been presented by Sullivan.[4]

Reference to Fig. 9 shows that the gas stream is pre-cooled to a greater degree than is possible in the low-temperature separation process, prior to expanding the mixture into the low-temperature separator. The minimum safe working temperature of carbon steel vessels and accessory equipment is minus 20 F, which is often attained with relative ease in this process. Lower temperatures may be employed only if the equipment is fabricated from nickel steel. By increasing the glycol circulation rate, the water dew point of the effluent gas can be depressed as much as 30 F below the temperature prevailing in the low-temperature separator.

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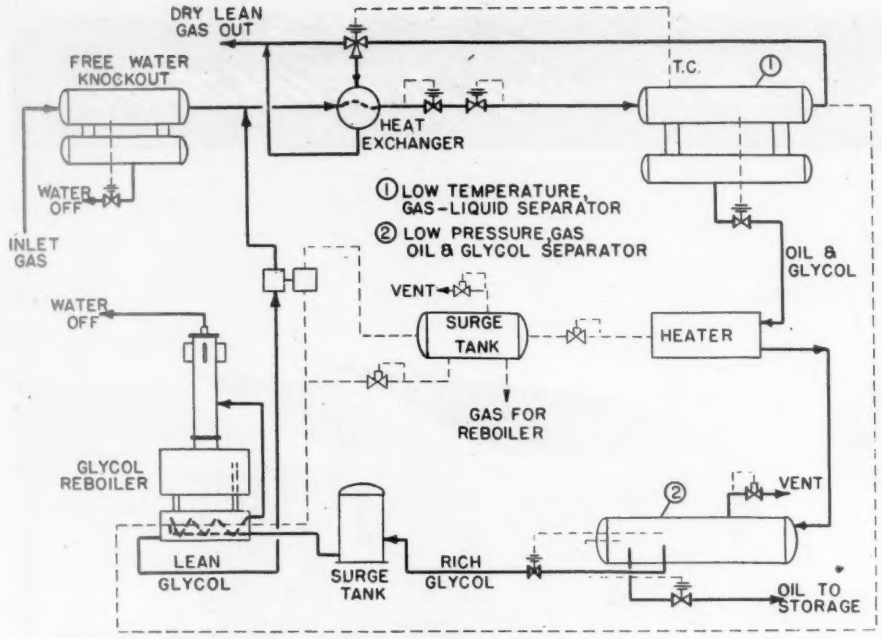

FIG. 9. Flow diagram of the glycol injection process.

fected by this process are even greater than those obtained by low-temperature separation, described above, particularly where fractional stabilization is employed. Furthermore, this process has relatively greater economic life in any given installation for, when pressures decline to the point where it is no longer possible to obtain adequate dehydration by means of low-temperature separation alone, the use of glycol compensates the deficiency.

Glycol consumption is a prominent factor in the operating cost of this process for it may be lost by vaporization into the gas stream and by solution in the hydrocarbon liquid. Of the three glycols most commonly available for use, namely, ethylene, diethylene, and triethylene glycols, comparative vaporization losses decrease substantially and solubility losses increase substantially in the order named. Therefore, diethylene glycol has been used in all commercial installations thus far, as a compromise. Overall glycol consumption approximates 0.05 per cent by weight, or less, based on stock tank condensate. A new development* promises to decrease consumption by employing triethylene glycol to minimize vaporization losses, and using controlled dilution prior to separation of the liquid phases to minimize solution losses.

Cost data on the dehydration processes discussed here have been presented by Campbell[1] and are of material assistance in evaluating their relative merits for specific installations. Glycol absorption is available at minimum cost. Low-temperature separation and glycol injection costs are greater but these may be amply justified in many high pressure applications. Adsorption is the most expensive of the four processes but, when properly designed and operated, produces virtually "bone dry" gas and is often selected for this reason.

Acknowledgment

The author is indebted to Black, Sivalls and Bryson, Inc., for permission to use the illustrations included in this article.

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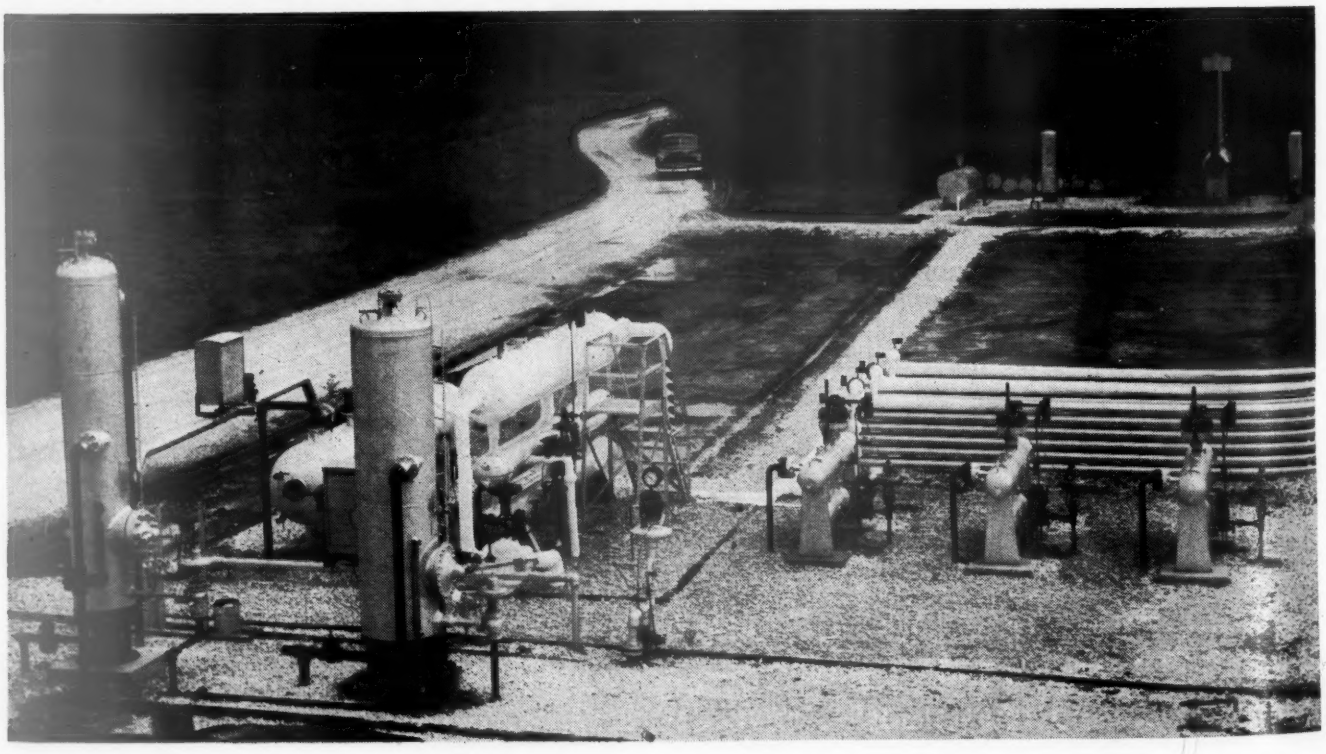
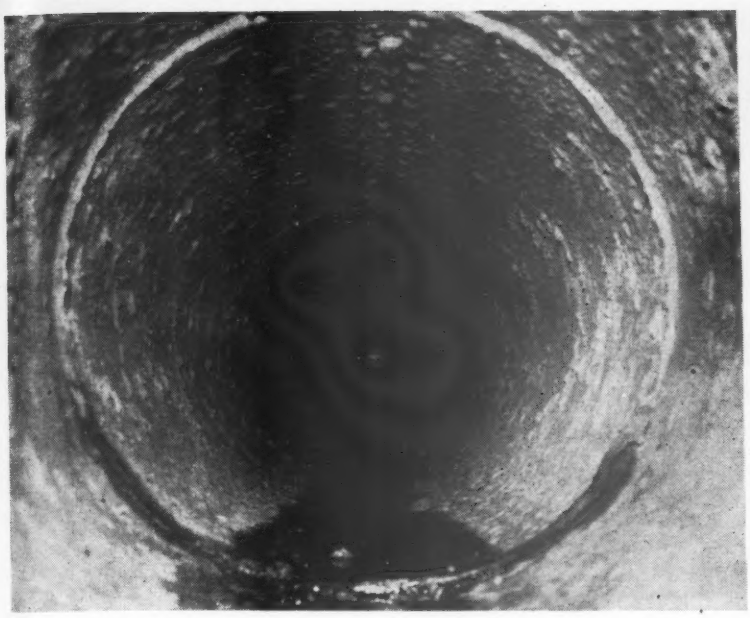
* * *

*Patents pending.

FIG. 10. Glycol injection installation in Southern Louisiana. Note glycol reconcentration facilities in background.





Typical pipe interior before cleaning.

Special pipe cleaner.

Cement-Mortar vs Line Replacement

Lining may be answer to replacement problem, which involves numerous factors such as determining extent and location of damage

RICHARD SNEDDON*

REPLACEMENT of oil or water lines is an expensive and inconvenient business for which most operators would really appreciate a satisfactory substitute. It seems that in almost any pipe line regardless of how long it has been in service or what its environmental conditions may be, there are irregular sections that appear to have escaped corrosive or abrasive action or any of the other influences that normally shorten pipe line life.

These areas are not easy to define, however, because the corrosion or abrasion may be internal and is consequently not revealed by casual inspection. As a result, any program of either total or partial replacement of old pipe in place must be preceded by a meticulous, difficult, and sometimes rather uncertain inspection, in order to determine the extent of the damage or the exact loci of the weakened sections; and, of necessity, in any replacement job there must be a sacrifice of good pipe.

It is also a fact that a pipe line replacement job, unless provision has been made for such eventualities in the original planning of the line, will cause an interruption or modification at least of normal line operations that can be costly, bothersome, or inconvenient, and sometimes all three at the same time.

Mounting experience would indicate that for many conditions the use of a cement-mortar lining as a protective coating on the inside of steel or cast-iron pipe is an effective and economical answer to the line replacement problem. As a matter of fact it is also recommended as a protection for new pipe and there is no doubt that it would extend the ultimate life of the line for many commodities and this, peculiarly enough, without reducing the line capacity. Actually, it would be expected that restrictions of the internal cross-section by the thickness of the coating would lower the rate of flow, but the fact is that the cement-mortar finish offers less frictional resistance to the stream and this difference in most instances more than makes up for the lesser cubical capacity of the line.

The cement-mortar lining procedure, known as the Tate process[1], can be adapted to field application by the use of special portable equipment, and new pipe, of course, can also be treated either *in situ* or at one of the licensee's plants. In the field, the line after cleaning is treated in sections of 300 ft or more, each section when necessary being temporarily bypassed by a substitute section of adequate size and length, with appropriate take-offs. The temporary line is tied into the system with the proper lengths and strengths of rubber hose to form stable and safe connections between the two.

Meantime, valves, tees, short bends, or other fittings are cut out of the main line section that is about to be treated, and are treated separately. A 5-ft length of pipe is also cut from either end of the main section to provide working space and to permit easy ingress and egress

*Editor, Pacific Coast.

[1]Pipe Linings, Inc.

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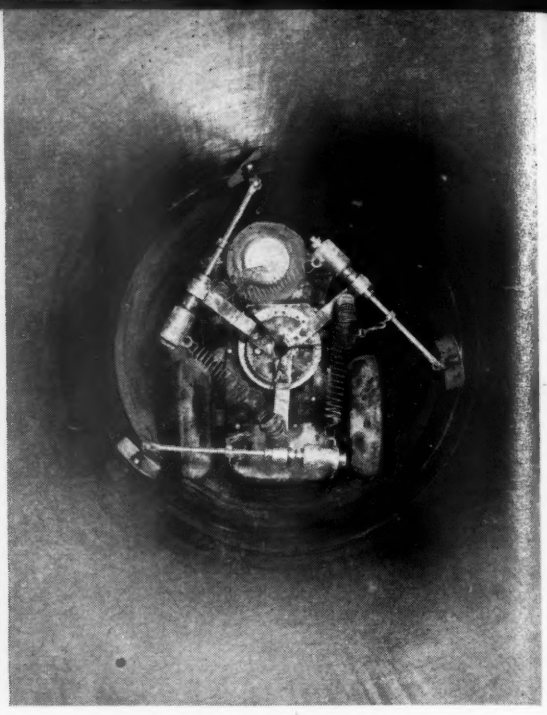
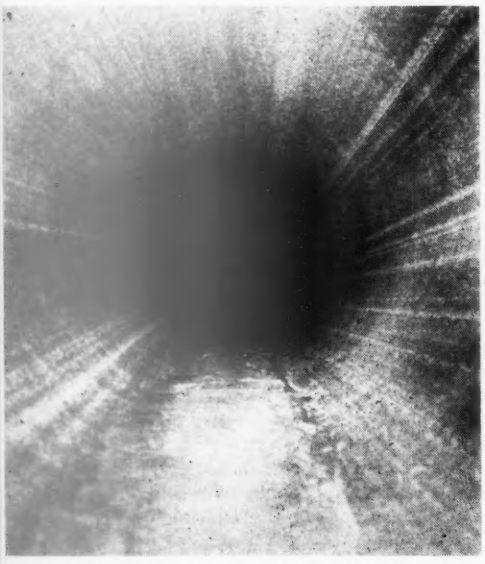


Centriline machine in 30-in. pipe.

of the cleaning tools and lining apparatus. A wire line is then threaded through the pipe and to this the various cleaning implements are attached. By means of portable power winches the cleaning devices are pulled back and forth through the line as required. They consist of a steel scraper to loosen tubercules and incrustations, a rubber swabbing tool to remove the loosened material, and a plug, slightly smaller in diameter than the inside diameter of the pipe, which is finally pulled through to expel the last vestige of scrapings.

Having cleaned the pipe, the cement-mortar lining process begins. The mortar mix is made up of one sack of Portland cement to 2 or 2½ sacks of fine sand mixed with water to the required consistency. This is fed into the open end of the pipe to be treated and is followed by the lining tool, which spreads a smooth, even coat, normally from 3/16 to ¼ in. thick, over the interior wall. The liner is kept centralized by e'liptical springs that are slightly larger when spread than the internal diameter of the pipe. It is equipped also with a perforated hollow skirt through which excess water is taken off and the setting process thus accelerated. The squeeze imparted to the cement mortar mix by the liner is of considerable intensity so that filling of all the joints, pitholes, and other indentations is assured, and a smooth, continuous, and uniform coating results.

Completed lining.



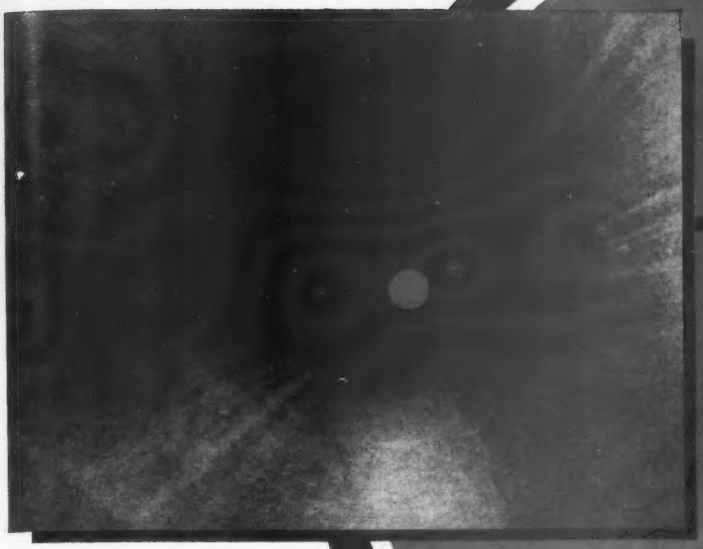
The process as above described applies only to pipe up to 16 in. in diam. For sizes in excess of that the so-called "Centrilining" system is used. This employs a mobile machine that travels in the line and applies a uniform internal coating by centrifugal force. The coat is troweled down automatically by a device that is built into the lining machine immediately following the applicator. The thickness of the coat is controlled by the speed of travel through the line. It produces the same effect as does the Tate process in the smaller lines and its effectiveness is attributable to the same basic advantages. The cleaning of the large diameter line pipe is performed by a hydraulic unit and it is not necessary as a rule to get down to bare metal to obtain maximum protection. It is required, however, that any water standing in the bottom of the pipe be removed.

As in the case of the smaller lines, the disruption of normal service is immeasurably shortened by the employment of a substitute section with corresponding outlets where suitable bypass arrangements have not been built in at the time of construction. Similarly, also, the pipe line can be cleaned and lined in place, regardless of whether it is on the ground or under it. New pipe may be treated either at the plant or in the field. In all instances there is full control over coat continuity and thickness and maximum term protection is thus assured.

An interesting example of actual application of the Tate process for the lining of water lines was the treatment of Tide Water Associated Oil Company's fire protection lines at Avon refinery, near San Francisco, California. The resort to cement-mortar lining in this case was based on flow tests and other observations on a trial installation. The flow was found to have increased 190 per cent, 240 per cent, and 70 per cent respectively, in sections of 8-in., 6-in., and 4-in. water lines. Discussion of results with other operators who had used the process developed the fact that the control of tuberculation was lasting and was not just a temporary accomplishment. A further recommendation was the discovery that the cost of cleaning and coating the inside of the pipe lines in question was only 40 per cent of the cost of total replacement, although the life expectancy of the cement-mortar lined pipe is about 20 years, which is at least equal to, and in all probability better than, that of the untreated pipe.

The contract as originally awarded[1] called for the cleaning and lining of 7449 ft of 4-in. line, 27,969 ft of 6-in. and 4214 ft of 8-in., all fire protection lines, carrying liquid with a high content of calcium chloride, together with some 2822 ft in 6-in. condensate and treated water lines carrying fluid with an average temperature of 180 F. These were standard steel lines and they had been in service from 20 to 25 years, so that, as might be expected, the cleaning job in itself presented quite a problem. It was necessary, indeed, to develop a special equipment to remove deeply imbedded salt incrustations, but once the techniques were established both the cleaning and lining processes moved along in good style.

Work was begun on August 20, 1951, and completed on December 4, 1951, with an average of 3030 ft of pipe being



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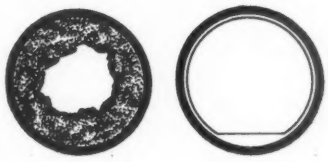

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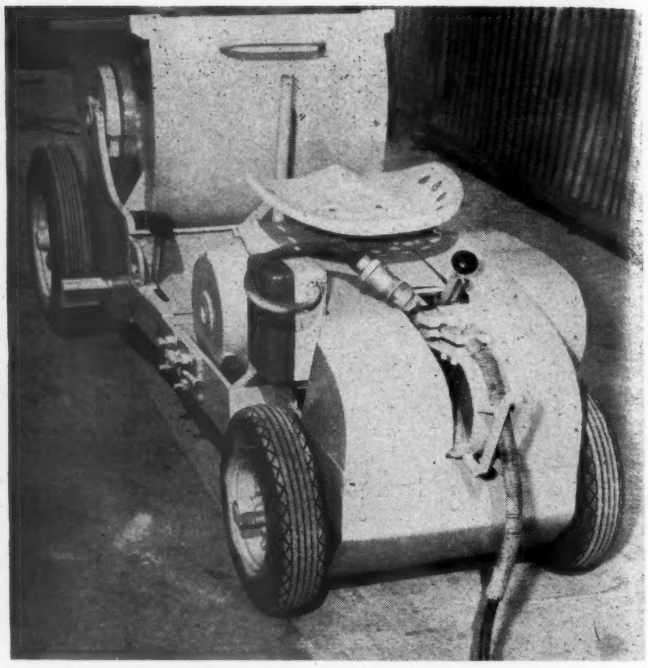
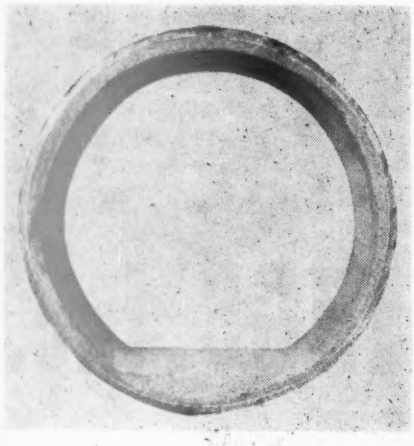


Electric powered mortar delivery unit for large pipe.

Mortar pump unit.



Heavy lining used for badly deteriorated pipe. Capable of withstanding high pressures.

lined per work week. This is below normal for the Tate process but that is accounted for by bad weather and other extraordinary circumstances. The material used for the lining was a Type 2 Portland cement with clean 20 to 30 mesh sand. The lines did not require a bypass as sections from 1000 to 2000 ft long could be taken out of service without adversely affecting the fire protective function. The decision in such matters, of course, rested with the proper authorities and no step was taken at any time that would tend to disrupt the water service in case of a fire or other emergency in which it might be required.

The cut out line sections were replaced and secured by welding split steel straps, which were coated with coal tar before backfilling. The equipment needed for the work consisted of the winch trucks that operated the pull-through cables during the cleaning operation and the application of the cement mortar mix; welding machines for cutting out the short work sections and replacing them; compressors to supply air for diverse purposes; utility trucks and trailers; water wagons, and the special tools used in the cleaning and lining.

The work crew consisted of a foreman, two winch operators, one engineer, a plumber welder, and five laborers. The job was slowed down to some extent, as indicated, by poor weather and by other developments that could not be foreseen but it was completed in good time, nonetheless, and with a minimum of difficulty.

It is estimated that the cement-mortar coated lines will last for at least 20 years at practically full line capacity. Additionally, it is asserted that no intermediate cleanings will be required because, besides stopping the corrosive and abrasive action on the pipe interior, the cement-mortar lining inhibits bacterial action so that maintenance and replacement costs are markedly reduced. Also, of course, reduced line friction and greater pumping volumes mean lower pumping costs.

The growing use of cement-mortar lining for pipes of many types and sizes where conditions permit is evidence in itself of the acceptance of the process as sound economical engineering, and there is little doubt that still further expansion of application will come with added experience. In the meantime the system is already well established on rational grounds and it has become a factor worthy of consideration in any pipe line problem involving the question of replacement of worn lines or extending the life of new ones. * * *

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Remote Automatic Gaging of Tanks

In recent years automatic gages have become widely accepted for use on pipe line systems

FRANK H. LOVE*

RECENT years have witnessed the widespread acceptance and use of automatic tank gages on pipe line systems. They have saved the gager many steps and made his task more pleasant particularly in sections of the country where winters are severe.

Automatic remote indicating tank gages can be divided into these types: (1) Selsyn motor gages, (2) step type, (3) potentiometer, and (4) gamma-ray radiation. The purpose of this article is to describe the several makes of gages under these types that are presently in use.

Selsyn Motor Gages

There are two types of selsyn motor gages, the single-motor and the double-motor. The double-motor gage is discussed first. In operation, two selsyns, mounted on the tank, are geared together and positioned by a sheave, the latter being driven by a tape or cable attached to a float. One selsyn is moved through its permissible angle of movement as the float travels from minimum to maximum liquid levels. The other selsyn is geared to rotate once for each foot of float travel. These two motors in the transmitter are connected in the conventional manner to two similar motors mounted in the receiver, which is situated remotely from the tank. A feature of the double-motor type is that one receiver may be connected to several transmitters through a suitable switching arrangement. Fig. 1 shows a wiring diagram in which the double-selsyn gage has seven common wires to each of four tanks and an additional power wire to each tank. The power wires should be of heavy copper and the rest lighter weight copper. One switching relay is required for each tank, and this is a 6-pole, normally open type. Completing the power circuit for a particular transmitter, by operating the selector switch, energizes and closes the relay, placing the transmitter selsyns in parallel with those of the receiver.

As a means of facilitating repair work on the gage system, telephone communication can be established between the receiver and transmitters by running a pair of wires in addition to those common to all transmitters. The telephone wires can be No. 18 wire. The usual method is to provide phone jacks at the receiver and transmitters. Battery or voice-powered telephones may be used.

The single-selsyn gage is mounted in the same manner as the double-selsyn. The transmitting selsyn, positioned by a float, makes one revolution for each foot of float travel. The receiving selsyn, which follows the motion of the transmitting selsyn, drives two rotating pointers through gears arranged so that the "inch" pointer rotates 360 deg for each rotation and the "foot" pointer rotates 360 deg or less for total height of the tank. In this type gage the transmitter and receiver are permanently connected and thus require a receiver for each tank.

In the case of the single-selsyn tank gage, four and five wires are required between the transmitter and receiver (see Fig. 2). If telephone service is established an additional wire is required, and the power wires should be of heavy copper and other wires of lighter weight copper.

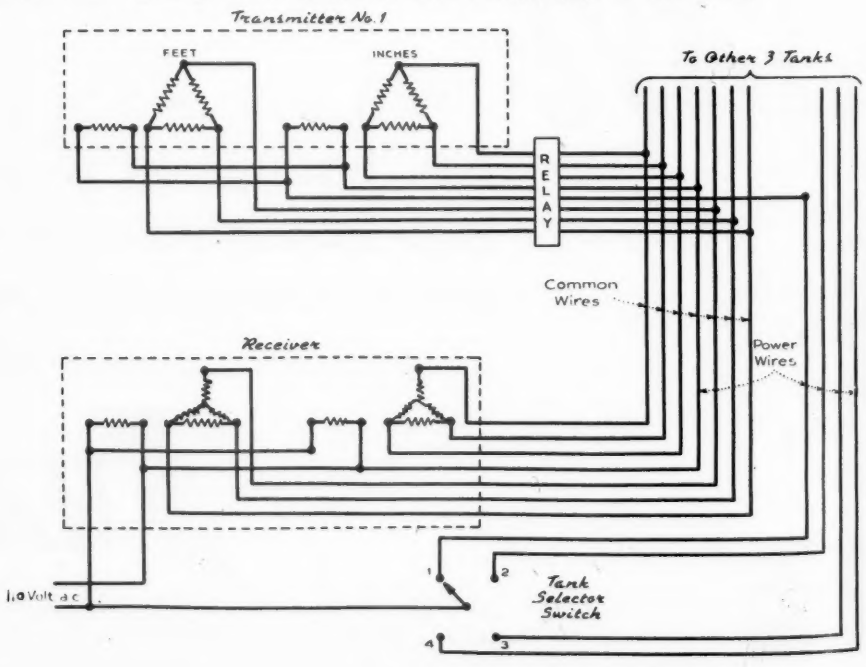
The following are the various makes of gages that use the selsyn principle:

Shand & Jurs Remote Gage. Shand & Jurs manufacture both the single and double-selsyn gages, as well as an electronic remote reading gage. The double-selsyn, or selective system, is employed in instances where a large number of tanks are involved, and the single-selsyn, or non-selective system, where only a few tanks are involved.

The double-selsyn system has two motors in each transmitter and two motors in the receiver. The transmitter motors are geared together so that one motor corresponds to the inch reading and the other to the foot reading of the gage tape. This transmitting unit is driven by a perforated tape. The inch motor is coupled directly to the tape through a sprocket and shaft and makes one complete revolution for each foot of change in the tank level. The foot motor is equipped with anti-backlash gears to assure accuracy and to hold its travel to one revolution for the full tank height.

The motors in the receiver are electrically interconnected to the transmitter motors through a series of relay

FIG. 1. Wiring diagram for connecting double-selsyn gage to four tanks.



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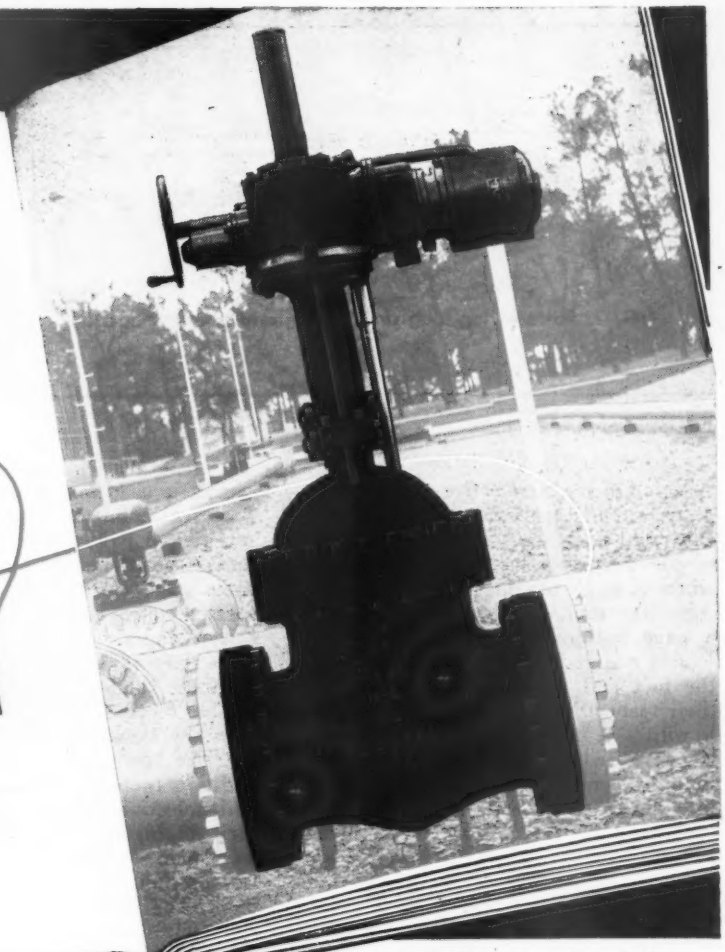

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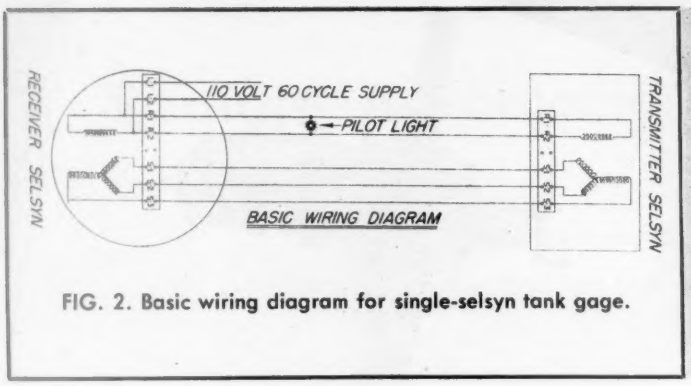
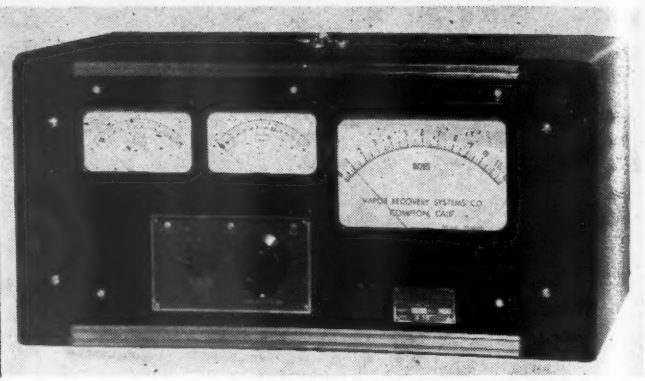


FIG. 2. Basic wiring diagram for single-selsyn tank gage.



Varec selector type, 10-tank receiver.

junction boxes. A selective switch on the receiver panel permits selection of the tank on which the gage reading is desired. This system is energized only when a gage reading is to be taken. After the tank is selected upon which a gage reading is desired, the spring loaded energizing switch is pressed and the foot and inch needles register, on their respective dials, the depth reading to within ⅛ in. By means of one or more selective switches as many tanks and their transmitters may be incorporated into the receiving station as desired. If the addition of more tanks is anticipated at a future date, provision can be made for leads in the original main cable.

A typical installation utilizes seven wires plus one additional lead per tank. Thus, a five-tank system would require 12 leads in the main cable; a seven-tank system, 14 leads, etc. The main line cable traverses the tank farm and connects the receiving panel with the relay junction boxes that serve the individual tanks. An eight-wire cable is required between the relay boxes and each transmitter.

The double-selsyn system may be operated continuously on any one tank for as long as desired; however, in most installations the spring loaded energizing switch is used at the receiver panel and the circuit energized only long enough to take the desired reading.

The single-selsyn system utilizes only one motor in the transmitter and one in the receiver; however, as the transmitting motor must make one revolution for each foot of change in the tank level, the system must remain energized constantly. This requires a separate receiver assembly for each transmitter, and the foot reading is obtained through a geared head in the receiver, which provides two needles, one for the indication of feet and the other for inches.

The single-selsyn system requires a five-lead cable from the transmitter to each corresponding receiver, but, as in the double-selsyn system, advantages can be taken of the duplicating leads in a large set-up and the total number of leads in the main cable reduced by the use of terminal boxes if this appears to be warranted.

Shand & Jurs have also developed an electronic remote reading gage. In this method a balanced Wheatstone Bridge circuit is used to indicate selectively at a central point the level in any number of tanks. A pair of potentiometers at the tank is positioned by the float using the same gage sprocket housing and perforated tape that are used with the selsyn gages. One potentiometer indicates the total reading in feet, the other gives the value of inches and eighths.

The receiver for this gage consists of a key switch cabinet and an indicator. The key switch cabinet contains, in addition to the necessary switches for tank selection, balancing potentiometers for bringing the total line resistance to a common standard for all tanks regardless of their distance from the gaging point. The indicator is a self-balancing slide wire servo-mechanism that operates in conjunction with the field potentiometers to complete the bridge circuit. Establishment of the null balance positions the indicating dial so that the proper value of depth measurement may be read accurately and easily. Two readings are required for the complete gage, one to obtain depth in feet and the second to get the precise value in inches and eighths.

The usefulness of this measuring instrument is also extended into the field of temperature indication. To arrive at the accurate volume in a tank of liquid, correction must be made for temperature. This temperature should be the average temperature within the tank as nearly as can be determined, and not the temperature taken from only one or two points. By adapting the resistance thermometer to the circuit of the electronic level indicator, it is possible to gage from a central location the level of the product and determine its temperature by remote means for an entire field of storage tanks. The resistance element itself may be a single bulb in a fixed well in the shell of the tank, or it may be several bulbs arranged in a series-parallel network to sample the temperature at varying depths and varying positions within the product. By this means it is possible to combine spot temperature readings and average readings without alteration of the indicator to accommodate varying amounts of resistance.

Transmitters for the selsyn and electronic systems are always mounted at eye level, and all gages involve a ground-level reading housing so that the perforated, graduated tape can be read at the tank as well as remotely.

Roach Gage. Roach Equipment Company manufactures both the single and double-selsyn gage. This particular design has an 18-in. diam cone bottom float made of galvanized sheet iron for general oil use. The transmitter may be mounted on top of the tank or at ground level. The transmitter selsyns are positioned by a perforated stainless steel tape traveling over a sprocket. A stainless steel wire or cable is used to connect the tape to the float. This arrangement reduces the length of the tape required and keeps the tape out of the tank vapor space. The gage does not have a ground level look box. The transmitter is encased in a explosion-proof housing, and telephone jacks are installed at the transmitter and receiver. The gage is arranged so that it can be adapted to the Varec ground level gage and by using this combination a ground level reading may be made.

Nelson Gage. Although the transmitter and receiver units of the Nelson gage contain only one selsyn, the operation is such that the results are that of the conventional double-selsyn type. The transmitter normally is mounted at tank top but could be mounted at ground level. It has two pointers, one for feet and the other for inches. The pointer shafts, which are positioned by conventional sheave-gear arrangement, extend downward into the transmitter case and carry a second pair of pointers. This second pair of pointers serves to position the single-selsyn in the transmitter. A 24-v direct-current motor rotates the selsyn motor by means of a spring-belt drive. All transmitter elements are immersed in transformer oil. Attached to the selsyn shaft are two vanes so arranged that when the shaft rotates one vane assumes a position almost parallel with the shaft due to movement of the vane through the oil, and the other vane feathers to a position perpendicular to the shaft. The direction of rotation of the selsyn determines which vane is parallel and which is perpendicular. The vanes are shaped so that one will strike the inch pointer when the selsyn rotates in one direction, and the other vane will strike the feet pointer when the selsyn rotates in the other direction. When a

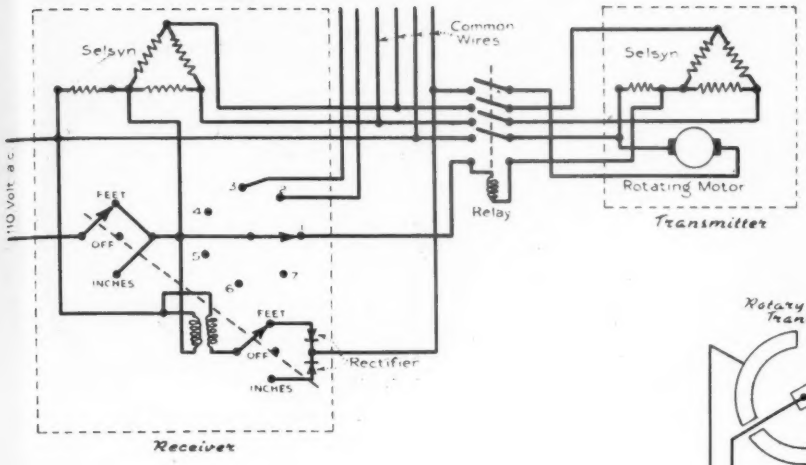
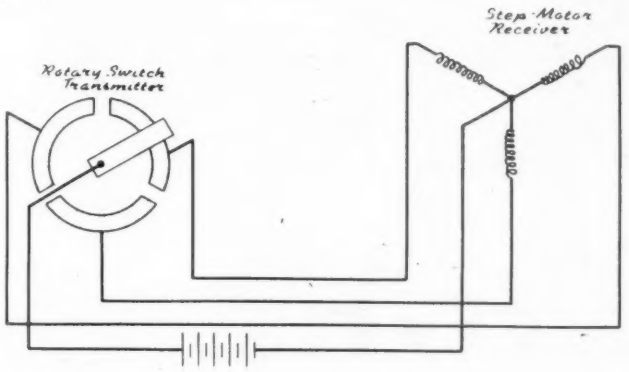


FIG. 3. Left, wiring diagram of Nelson selsyn type gage.

FIG. 4. Below, schematic circuit of step-motor gage.



pointer is struck, the driving spring-belt acts as a clutch, the d-c motor continues to rotate, but the selsyn is held in a position determined by the pointer. From this it is seen that the one selsyn may be used to indicate both "feet" and "inches" by changing the polarity of the direct current to the driving motor and by suitable switching arrangement on the selsyn.

The wiring arrangement is shown in Fig. 3. Five wires are required for the first tank with one additional wire for each additional tank. The two selsyn field wires may be No. 14, the others should be No. 10 or No. 12, depending on the distance between transmitter and receiver. There is no limit to the number of tanks that can be connected to the receiver.

Natasco Gage. The Natasco remote reading tank gage is a simple a-c selsyn system consisting of one motor in the transmitter and one motor in the receiver. The transmitter selsyn does not run as a motor but is rotated mechanically by a drive motor, the pulley of each motor being connected with a spring belt. The motor in the receiver can be connected to an unlimited number of transmitters. A drive pulley is attached to the drive shaft and is operated by float and float line. The float rises and falls with the fluid level of the tank and positions the pointers accordingly, which shows with the use of two pointers the feet, inches, and fractions on the transmitter dial.

The drive shaft by its rotation not only positions the feet and inches pointers on the dial face, but also positions by means of a gear train the feet and inches arms, respectively. At the end of each arm a short pin extends downward, which acts as a stop for the purpose of stopping the movement of the feet and inches vanes, which are rotated by the transmitter selsyn. Therefore, the feet and inches arms indicate at all times the exact float level or fluid level of the tank. When the system is energized to gage feet the drive motor rotates in a clockwise direction, which similarly rotates the selsyn until the feet vane engages the feet stop pin. The stoppage of the transmitter selsyn, because of selsyn characteristics, instantly stops the selsyn at the receiving station and the fluid depth in feet is shown on the receiver dial. To gage inches and fractions the drive motor rotates in a counter-clockwise direction with the inches stop pin engaging the inches vane and again stopping the selsyn rotation. This position is transmitted to the receiver selsyn and the inches measurement is shown on the dial.

The system requires a 110-volt a-c source of power. Five wires are used common between the receiver and each transmitter. One additional control wire is required for each tank.

Step Type Gages

The several makes of step or trailing-type gages operate basically on the same principle. A small permanent magnet motor, with three pairs of poles, or a trailing relay system, is connected to a power source through a rotary switch in the gage transmitter. This is shown in Fig. 4. With the rotating brush on a switch segment or contact, one pair of poles in the motor is energized and the motor magnet assumes the position coincident with the magnetic field. If two pairs of poles become energized at the same time, which occurs when the rotating brush is passing from one switch segment to the next and is in contact with both, the motor magnet assumes a position midway between the energized poles.

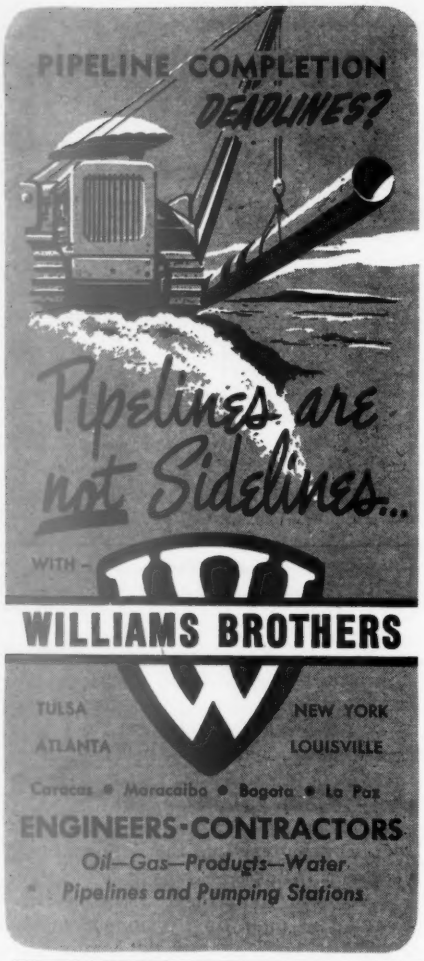
The step-motor gages are arranged so that a float-travel of ⅛ in. moves the rotary switch one segment. The intermediate positions then indicate level changes of 1/16 in.

Nelson Step-Motor Gage. The transmitter of the Nelson step-motor gage is a 24-pole rotary switch, driven by the float through a perforated tape, sprocket, and suitable gears. The transmitter is mounted on the tank at ground level. By filling the transmitter with transformer oil the unit is made explosion-proof. This also prevents condensation on the inside of the glass face.

The gages are powered by batteries, usually 12 v, and should have no power failure. If power were disconnected, however, the receiver would stay in step if liquid level did not increase or decrease more than 3/16 in. during the time the power was off. This gage may be powered with 15 volts a-c and provided with a voltage failure relay that will connect a battery into the circuit in case of power failure.

Telematic Stepping or Trailing Type Gage. The operating principle of the Telematic gage essentially is the same as that of the Nelson gage. The transmitter unit, positioned by a float, contains two rotary switches. The "inch" switch makes one revolution per foot of float travel, and the "foot" switch is geared to make one revolution for full tank height float travel. The "inch" switch has two sets of contacts, the outer row with 96 contacts, the inner row with 12 segment contacts forming a complete circle. Each segment subtends eight of the contacts in the outer row. The segments then denote 1-in. increments and there is an outer contact for every ⅛ in. through 1 ft. Every eighth outer contact is electrically connected, thus there are eight groups of 12 contacts. On the "foot" switch every tenth contact is connected together forming five groups of 10 contacts; the inner row of contacts are five segments forming a complete circle. The outer contacts denote 1-ft float travel whereas the segments, subtending 10 outer contacts, represent a 10-ft float travel. Fig. 5 is a drawing showing the layout of the switch plates.

One wire is required between the transmitter and receiver for each segment and each group of contacts, 35 wires in all. Add to this two wires for an indexing mechanism that operates the "zero" and "⅞" fraction-inch indicator, the "hot" and the "ground" wires, and thus it is seen that a total of 39 wires are required to each gage transmitter. Thirty-eight wires are common in a multi-gage arrangement but the "hot" wire is individual for each transmitter. A rotary switch or push-button system



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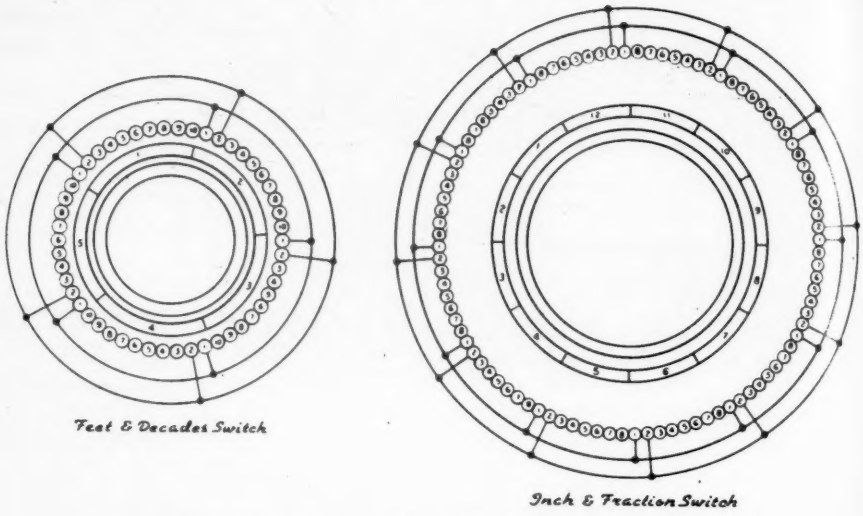

FIG. 5. Switch plates of Telematic gage transmitter.

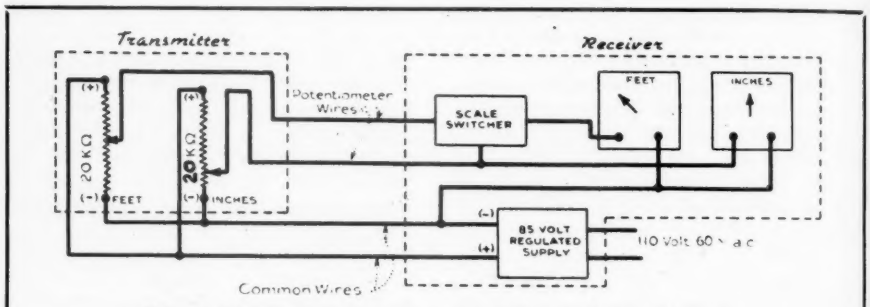

FIG. 6. Schematic wiring diagram of Varec electronic gage.

is used for dispatching the "hot" wires to 38-pole relays that connect the transmitters to the common wire system.

The transmitter is driven through a magnetic clutch. Thus the measured product is excluded from the working parts, which are oil-immersed. On loss of immersion oil, a float switch makes the gage inoperative. Tape entrance is at the tank bottom where the float is restrained from the bottom rather than suspended. This is for the purpose of keeping the tape "wet" and eliminating the corrosion hazard incurred in the vapor space.

The receiver is equipped with the selector switch mentioned, a push button to turn power on for reading the gage, and, if communication between receiver and tanks is desired, a phone jack may be provided. This last feature requires two additional common wires in the system. The gage reading mechanism consists of 35 relays each connected to a segment or contact group in the transmitter. When energized the relays turn on 6-v lights mounted behind plastic numerals, which indicate the gage by showing the "decade of feet", "foot within the decade", "inch within the foot", and "fraction of inch".

Varec Electronic Gager. The Varec electronic gager operates on the principles of measuring the output of voltage dividers, which are positioned by the float and tape of a float type tank gage. The transmitter is situated at the tank and contains two Helipot potentiometers, which are geared together and driven by the tape of the automatic tank gage. One potentiometer is of the 360-deg type and is directly driven by a sheave to rotate once for each foot change of liquid level. The output of this potentiometer is connected to a receiving voltmeter calibrated from 1 to 12 in. in increments of ⅛ in. The other potentiometer is of the 10 turn helical type and is geared to the shaft of the "inch" potentiometer so that it will complete its 10 turns while the "inch" pot makes 60 turns. The output of the helical pot is connected to receiving voltmeters calibrated from 1 ft to 60 ft. Each pot is 20,000 ohms in resistance and is connected across a regulated power supply of 85 volts.

Two different types of instruments are available employing systems of field wiring. In one system, all transmitters are powered simultaneously. One positive and one negative wire is common to all transmitters. An "inch" and a "foot" return from each tank complete the circuit. For a 10-tank installation, 22 wires would be connected to the receiver.

The other system utilizes selective switching. Only one transmitter is powered at a time. One "inch" wire and one "foot" wire common to all transmitters are used in this system. A relay is incorporated at each transmitter so that all transmitters except the one at the tank being gaged are out of the cir-

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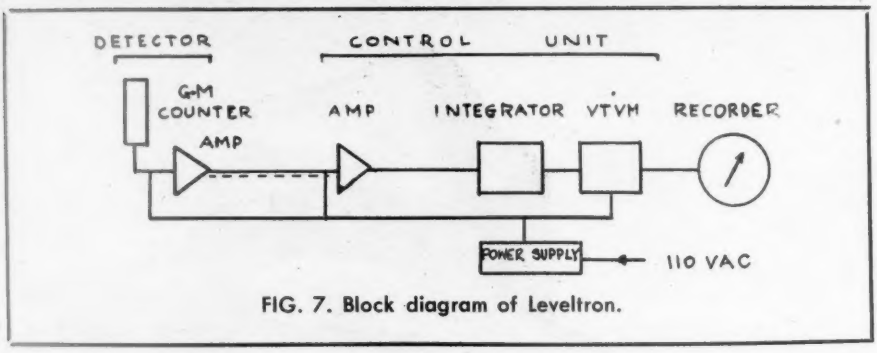

FIG. 7. Block diagram of Leveltron.

cuit. As few as 12 wires are required for a 24-tank installation.

The potentiometers are mechanically positioned by the tape at all times, therefore power failure will not influence the mechanical action and correct level indications are immediately available as soon as power is restored.

The Varec electronic receiver incorporates a scale-jump arrangement by which the needle on the "foot" voltmeter remains stationary on each foot indication and advances in 1-ft increments for each revolution of the "inch" pot. This is accomplished by applying the "inch" voltage to a vacuum tube whose output produces a voltage rise across a resistor in series with the "foot" voltmeter. This voltage is opposite and equal to "foot" voltage increase until the "inch" pot completes its revolution and the "inch" voltage drops back to zero. At this time the reading on the "foot" voltmeter automatically steps to the next successive foot.

Gamma-Ray Radiation

Leveltron. Functionally, the Leveltron is an electronic device designed specifically to measure the gamma-ray radiation intensity. (See Fig. 7). The heart of the unit is a Geiger-Mueller counter that converts gamma radiation into electrical quantities. The output of the counter is electrical impulses that vary in number per second directly with the radiation intensity. These pulses are amplified and shaped by the amplifiers in the detector and control unit and then integrated to produce a d-c voltage that is a function of the number of pulses per second, or effectively, a function of the radiation intensity at the counter. This d-c voltage is applied to a bridge type vacuum tube voltmeter with zeroing and range controls and its output can then be used to activate controllers, alarms, or recorders. The unit is completely self-contained and is operated from 11-v a-c, 50-60 cps supply, requiring approximately 100 watts input power.

The fluid level within the vessel is determined as a function of the measurable gamma-ray radiation at the outside of the vessel from a source of radiation within the fluid in the vessel. The variation in the radiation intensity at the outside of the vessel as the fluid level changes is used as an indication of the fluid level, or can be used to actuate other mechanisms to hold that fluid at a fixed position.

The Leveltron is constructed in two units: (1) An explosion-proof detector head for installation on the tank, and (2) the remote control unit, which normally is installed in the control house. All operating controls are installed on the control unit, eliminating the need for adjustments at the tank unit.

Two basic types of installation are made: (1) Wide range level control, and (2) narrow range level control. Both types use the same instrument, the difference being in the range of fluid level over which the control is available. The smaller the level range, or the narrower the level limits, the more accurate becomes the indication and control of the fluid level. Either type installation can operate a limit alarm signal or provide voltage to operate an electronic-pneumatic recorder-controller. * * *

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Checking the Cathodic Protective System

An installation may not be giving the protection for which it was intended and regular examinations will reveal the fact

WILLIAM E. HUDDLESTON

A PIPE LINE system that is being protected from external corrosion cathodically should be checked periodically. A pipe line operator can very well invest considerable sums of money in the engineering, planning, installation, and operation of an extensive cathodic protective system only to discover later that his pipe line system is not actually being protected against external corrosion.

In making periodic inspections it is suggested that the overall protective spread be checked first. If observations disclose that the pipe is 100 per cent protected the periodic check may be completed by making a routine inspection of protective equipment and ground bed facilities.

In event the pipe line is found to be inadequately protected, or entirely unprotected, in certain areas, it is, of course, necessary to start localizing the cause of trouble in order to rectify it and restore the line to full protection.

There are numerous things that can happen to a pipe line to disrupt a perfectly good cathodic protective system, many of which are trivial and therefore can be easily avoided. A few such contingencies are: (1) Insulated flanges may become "short circuited" from one cause or another; (2) contact might be accidentally established with a foreign pipe line or other structure entirely without the pipe line owner's knowledge; (3) changes may be made in the owners pipe line system by workmen who are unmindful of the fact that they can "foul up" the cathodic protection by making pipe changes indiscriminantly; (4) the indicating instruments on a rectifier may become defective, so that the meter pointers will lodge permanently at or near the normal operating range and thereby convey a false indication of the rectifier output, and (5) subsequent observations may disclose that errors in the original design resulted in the apparent loss of cathodic protection.

A "shorted" insulating flange or accidental contact with a foreign pipe line or other metallic structure may not be easily detected, for they will not always produce a noticeable change in the rectifier output, yet such contingencies usually will cause a substantial portion of the protective energy to be diverted from the pipe line to the foreign structure in such proportions that neither will be protected properly against corrosion.

An interesting experience is cited in the case of a large diameter transmission line that passes through a metropolitan area, where all underground metallic structures are constantly subjected to severe electrolysis from stray current action. The pipe line was well coated and insulated, and extreme vigilance was exercised during the laying operations to make sure that adequate clearance was obtained to all adjacent and crossing metallic structures such as cables, water mains, conduits, service lines, sewer ducts, etc. Within a few months following completion of construction a cathodic survey was conducted, during which it was found that the pipe line was entirely clear from all foreign structures, the pipe was exceptionally well coated, and the entire line was well insulated as evidenced by the small cathodic loads that would be required to attain full protection of the pipe. Within a few weeks after the survey of load requirements, permanent rectifying equipment was installed, and in attempting to adjust the rectifiers for optimum outputs it was not possible to bring the pipe potential to protective values, in fact, it was not even possible to produce the proper pipe polarity throughout approximately two-thirds of the normal spread area of one rectifier. A thorough investigation revealed that the loss of cathodic protection was due to: (1) Changes in a plant piping, whereby an insulating flange was inadvertently "short circuited," and (2) the settlement of a large gate valve, sufficiently to shear the bolt insulation and "short" the insulated flanges. After repairs to the insulating flanges the proper pipe polarity was immediately restored and full protection was obtained.

A similar case was experienced with the second cathodic rectifier on this pipe line although in this case the pipe polarity was never reversed. Investigations disclosed that the transmission line had settled sufficiently to come in contact with a number of uncoated service lines and one water main that crossed under the transmission line. During excavations it was noted that the service lines were in a strain from the weight of the transmission line and it is rather fortunate that this was discovered, for further strain might have broken the service lines and caused considerable damages.

In this case also, protection was at once restored to the transmission line following repairs, and as a result of these experiences the pipe line operator has made it mandatory to check the condition of the cathodic protective system periodically.

Fig. 1 shows an engineer locating foreign line contacts under pavement, using a sensitive electronic instrument. It is important that the exact point of contact be determined in order to minimize excavations in such places.

Cathodic rectifiers that are in service on transmission pipe lines may be checked regularly by the aerial patrol if a suitable indicating device is used

The Author

William E. Huddleston, pipe line corrosion consultant, has had 20 years pipe line experience, 16 years of which have been devoted exclusively to the prevention of external pipe line corrosion. He is a graduate of the University of Nebraska with a BS degree in electrical engineering. During the last 8 years he has installed cathodic protection on approximately 5000 miles of pipe lines. He lives in Bartlesville, Oklahoma.

FIG. 1. Locating foreign line contacts under pavement with an electronic detector.

EXCLUSIVE

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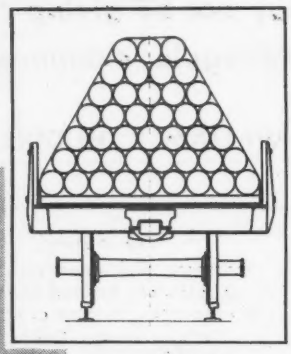
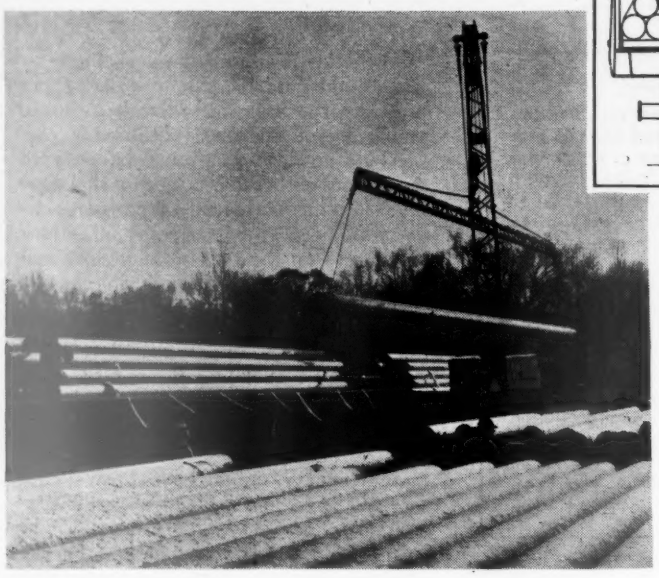


Cross-sectional drawing of pyramid loading.



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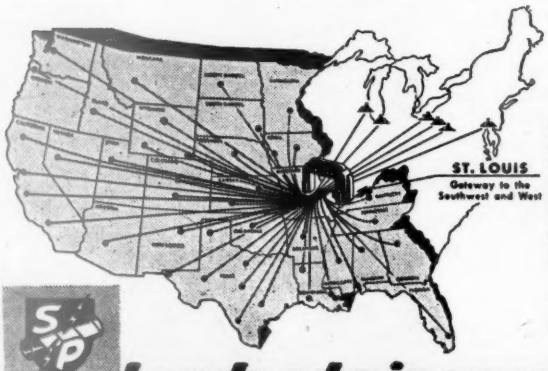

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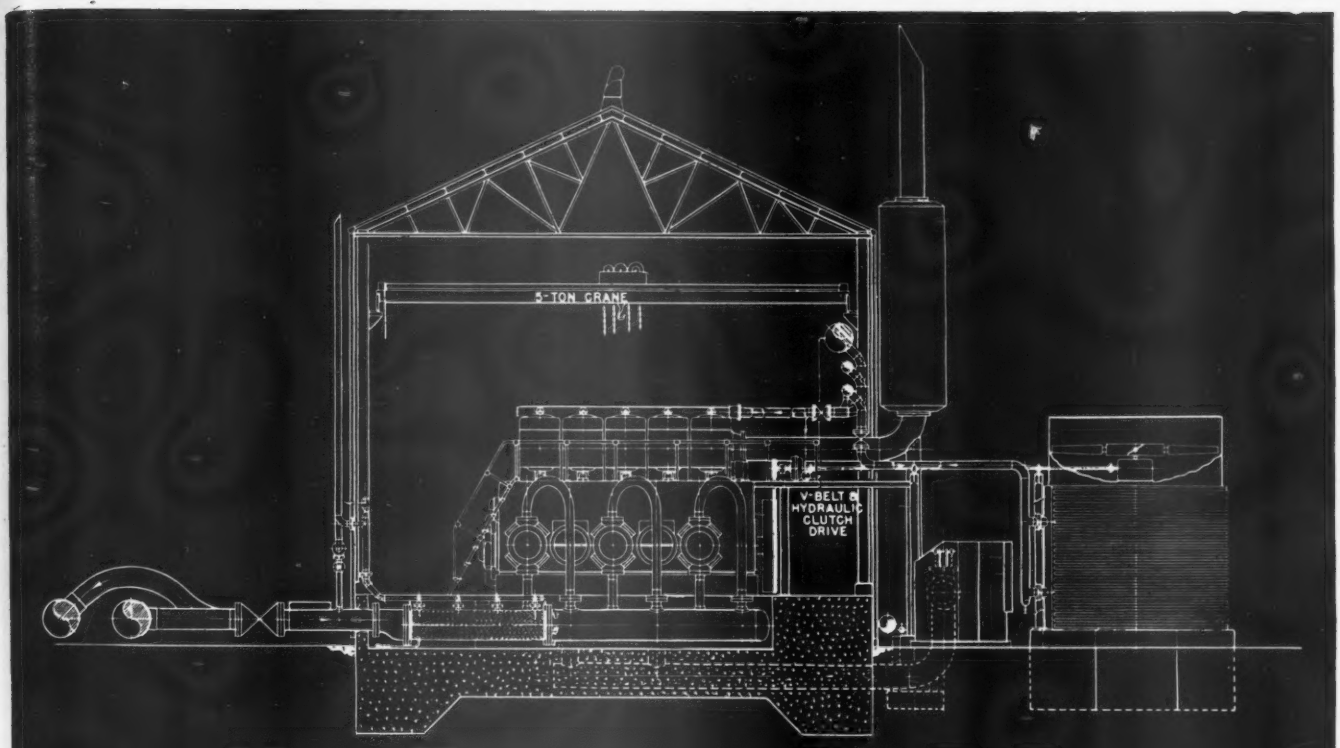
FIG. 2. Device for indicating rectifier operation for aerial patrol.

FIG. 3. Engineer making rapid check on condition of cathodic protection.

to show that the rectifier is functioning properly. Such a device is shown in Fig. 2. It is desirable that the indicating device be designed to show that the proper rectifier load is being delivered, which feature is usually accomplished by means of a relay that is built in the signal circuit. Obviously, this piece of equipment likewise should be checked periodically, to make sure that it is properly adjusted to function within the desired range of d-c output.

The cathodic protection on very large pipe line systems can be checked most rapidly if permanent test wire stations are installed at strategic locations throughout the pipeline system. Such facilities are shown in Fig. 3, wherein L. H. Heverly is shown making a routine check of the cathodic protection on the Great Lakes Pipe Line system. * * *



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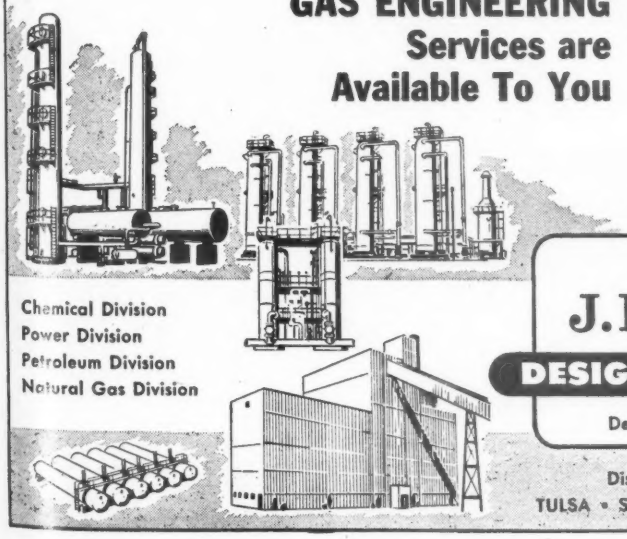

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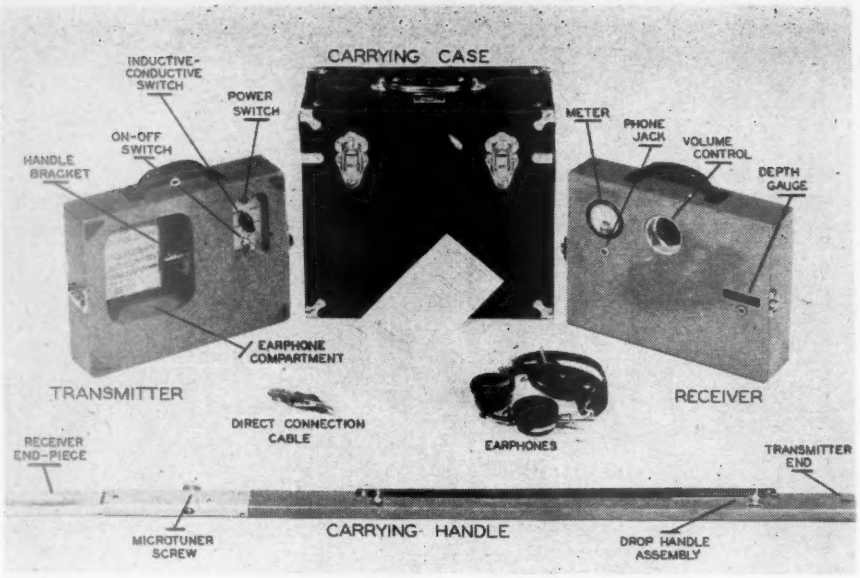


FIG. 1. Component parts and controls of an electronic pipe locator.

Pipe Locator Helps With Many Problems

Construction features and operating principles of equipment—Solutions to specific problems

HERBERT L. EGGLESTON, JR.

EXCLUSIVE

DURING the last four or five years oil and gas companies across the nation have become very aware of the fact that some sort of locating instrument is of great importance in their daily operations. This is apparent when one learns that practically all major companies and a good many of the smaller ones have pipe locators in operation through several departments; namely, pipe line departments, for use ahead of trenching machines in pipe laying operations, right-of-way departments for use in the mapping and surveying of existing lines, and electrical departments for assistance in the installation and maintenance of cathodic protection systems.

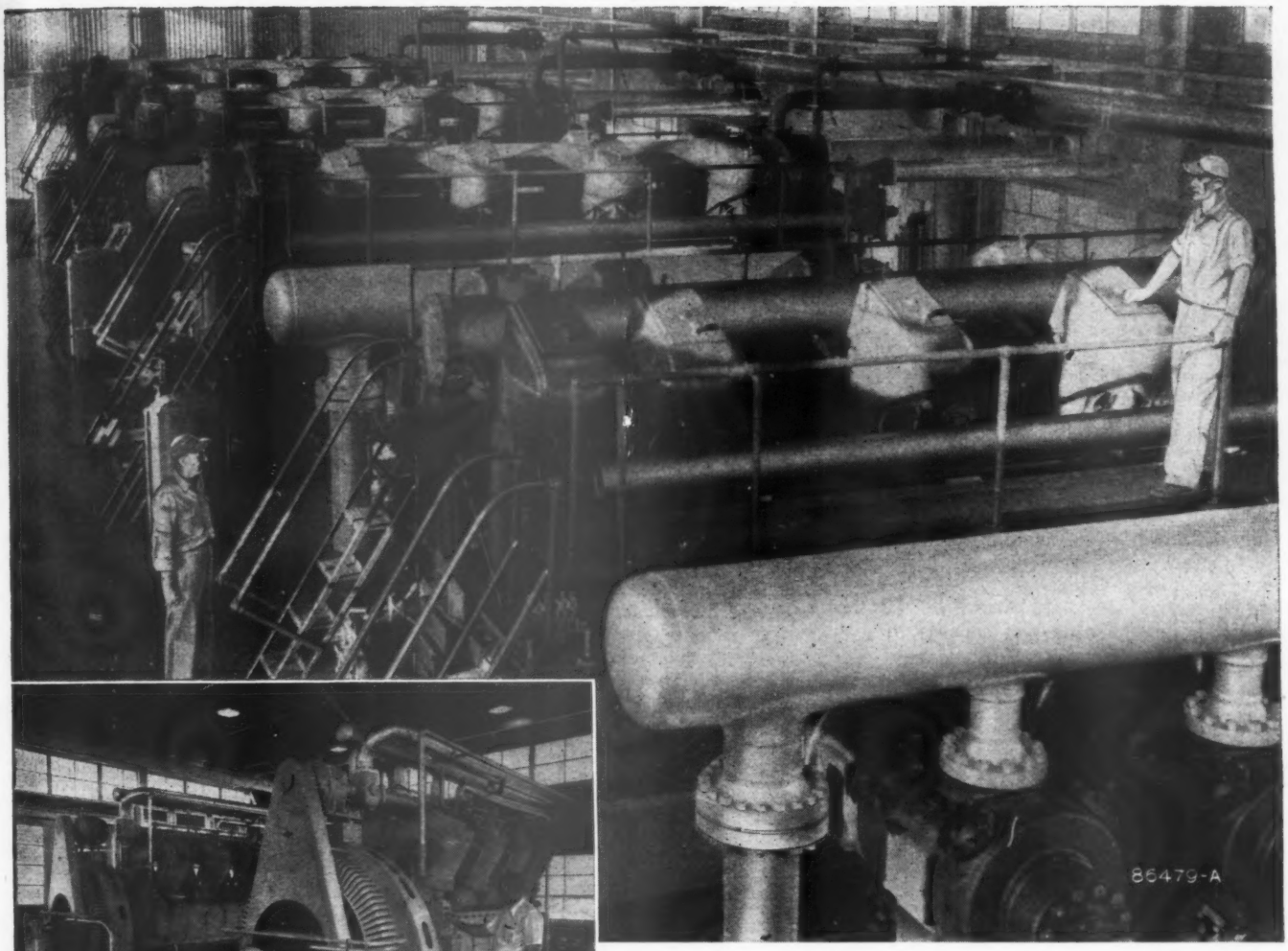
If nothing more this discussion may serve to acquaint the operator with the locating equipment he is using and assist him in solving some of the specific problems that confront him as a petroleum man.

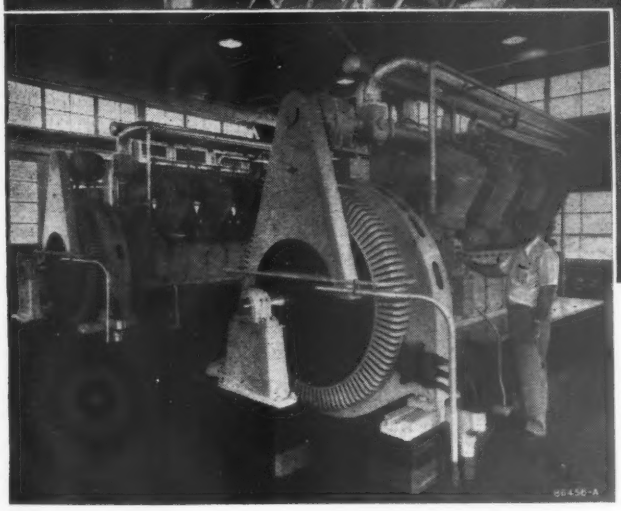
A pipe locator is called upon to solve any number of varied problems but we can list a few of the major requirements of the instrument.

1. Accurately pin-point the location of any given pipe line, cable, or conduit.
2. Approximate the depth of the above.
3. Locate all laterals and the exact point at which they tie-in to the main line.
4. Separate two lines that are close together. (Note: This is the most important requirement to a petroleum man because of the magnitude of parallel lines and their proximity to one another.)
5. Locate the point at which a pipe dead-ends.
6. Locate valves, gates, fittings, or

FIG. 2. The transmitting unit.

FIG. 3. The receiving unit.





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other buried objects that present a metallic mass to the locator.

Of course the modern two-box locator is capable of fulfilling all these requirements in 85 or 90 per cent of the cases, and with the constant research going on and continual progress being made in the field of electronics 98 or 99 per cent success will some day be realized.

Perhaps if we take a careful look at the construction features of the pipe locator and the principles of operation we can then understand its limitations and see why, at the present time, special procedures must be used to solve basic problems that have been complicated by unusual circumstances.

Fig. 1 shows the five basic components of a modern pipe locator: The transmitting unit, receiving unit, carrying handle, earphones, and direct connection cable. Also shown are the controls and devices that enable the operator to adapt the instrument to each and every locating problem.

The transmitting unit as shown in Fig. 2 is quite simple and consists of three basic components: (1) The oscillator or signal generator, (2) the power supply, and (3) the antenna or loop. The power supply consists of two 45-volt "B" batteries that supply plate voltage to the single tube and one 1½-v flashlight cell that supplies the filament voltage. The circuit is designed to oscillate at approximately 100 kc and this is radiated into the air and ground by means of a simple antenna. The antenna loop is wound in rectangular form and fitted into the inside perimeter of the box. The oscillator coil is used only when a direct connection is made to the pipe and that particular operation will be explained more clearly with the aid of a subsequent diagram.

The receiving unit, Fig. 3 is slightly more complex, consisting of a receiving antenna, and oscillator-converter section, amplifier, earphones, and indicating instrument and accompanying power supply. In operation, at the time the receiving antenna comes in contact with the lines of force from the transmitting antenna, currents are induced and the 100-kc signal is in effect received and enters the oscillator converter section. There it is mixed and converted to an 800-cycle note, amplified, and finally appears as a tone in the earphones or a deflection on the indicator.

By coupling the receiver and the transmitter with the carrying handle the locator is ready to operate as an induction balance. Fig. 4 shows the instrument in this operation being used to locate pipes with no conductive hook-up. This is shown diagrammatically in Fig. 5.

The transmitter is mounted vertically on one end of the handle in a fixed position. The receiver is mounted horizontally on the other end and can be rotated very slightly in the directions indicated by the arrows by turning the thumb screw on the connecting handle. With the transmitter on, while standing in an area free of pipes or underground metallic structures, the 100-kc signal is radiated through the air and into the ground. These lines of force also cut the receiver antenna and induce currents that produce a signal in the phones. But by rotating the receiver by means of the microtuner screw, the set can be balanced inductively and in one particular position a null (point of no signal) is achieved.

In other words, you have tuned the set, for a given ground condition. Then when you walk over a pipe, there is a change in the amount of ground conductivity you have tuned to, and the induction balance is upset, producing a tone in the phones and a deflection on the indicator. As the back box or transmitter is the energizing unit, maximum lines of force will be cutting the pipe when this box is directly above it. Therefore, when the tone is at a maximum or the reading is at its highest point, the pipe must be directly below the transmitting unit.

It follows that to receive a maximum signal the pipe must be crossed at right angles. In other words, 90 deg between the carrying handle and the line of the pipe in a horizontal plane; however, pipes can be picked up even though the

FIG. 4. The transmitting and receiving units operated as an induction balance.

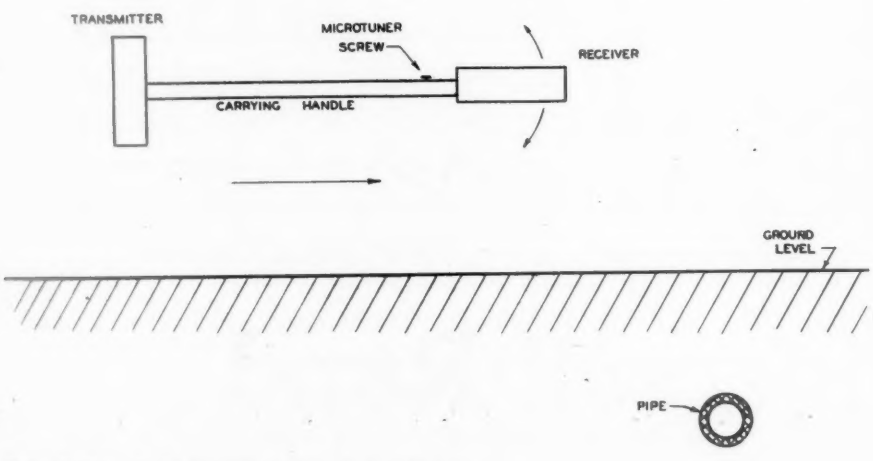


FIG. 5. The pipe locator as an induction balance.

The Author

Herbert L. Eggleston, Jr., is sales manager of The Goldak Company, Glendale, California, manufacturers of pipe locators. He is a graduate of Stanford University with a degree in industrial engineering. He majored in mechanical engineering at Glendale College, and served three years as an officer with the Army Air Force in Belgium and Germany. He flew 49 missions and was awarded the Air Medal with five Oak Leaf Clusters as well as the Distinguished Flying Cross.

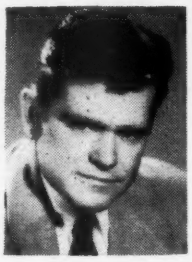
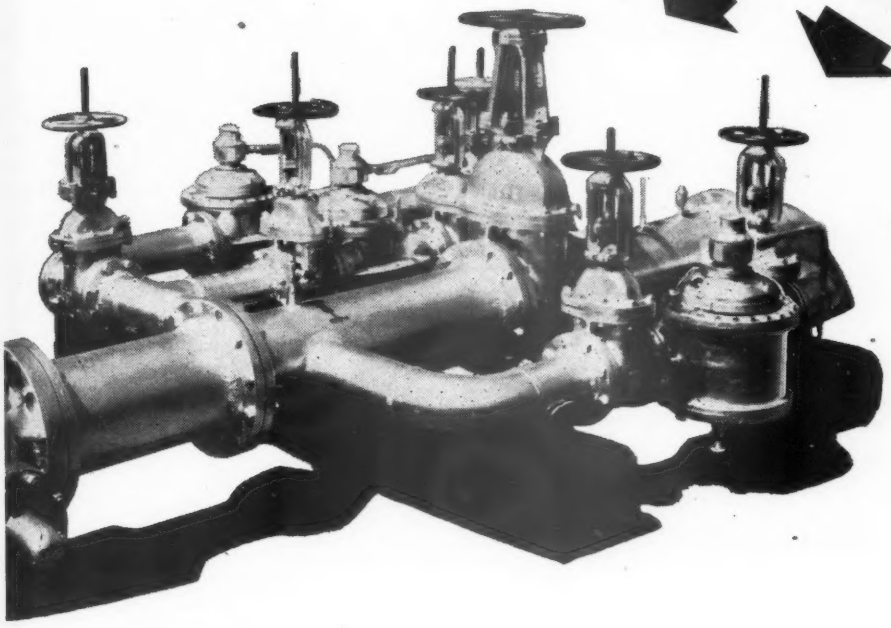


FIG. 6. The tracing operation.

ACCURATE PIPE LINE MEASUREMENT



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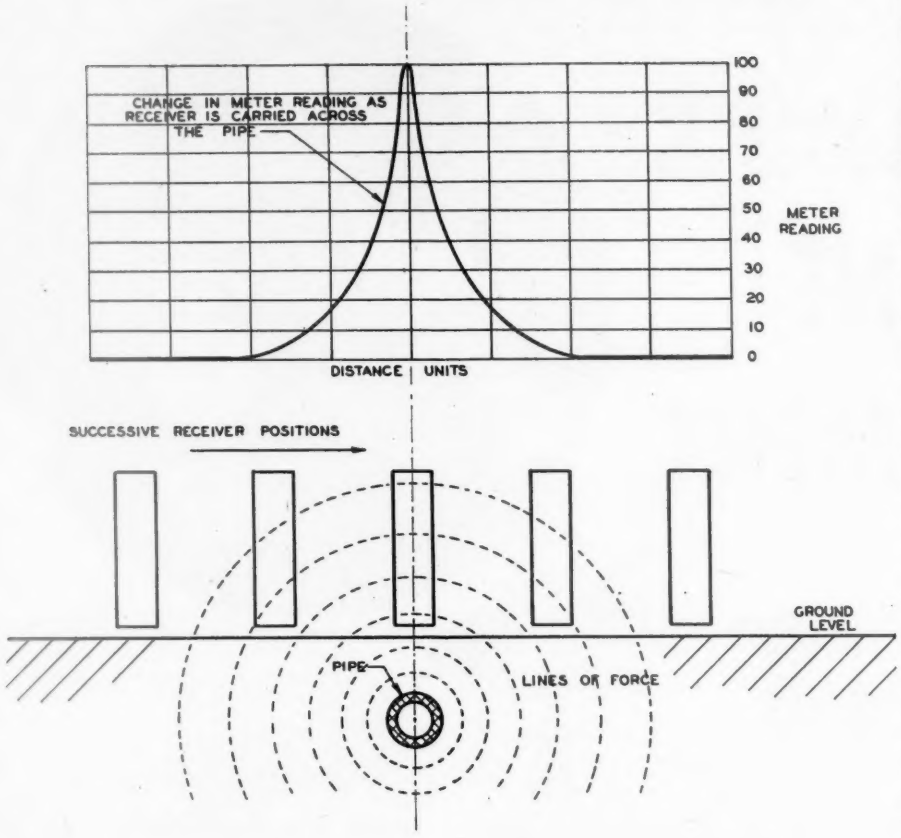


FIG. 7. Curve showing the change in meter reading during the tracing operation.

kept on the indicator, the pipe can be traced.

A simpler and much more effective method of tracing a line, however, is by using the boxes separated. After the line is located, the transmitter is disconnected from the handle and set over and above the pipe and parallel to it. The receiver is also taken off the handle and carried by the operator.

This operation is shown photographically in Fig. 6. The transmitter is shown placed over a line and in this position it will induce a signal into the ground, which is carried by the pipe itself. Then, whenever the receiver box is over the energized pipe, the lines of force set up by the transmitter and surrounding the pipe cut the receiver antenna and a signal results. The manner in which the lines of force cut the receiver antenna is shown graphically in Fig. 7. The transmitter or energizer, not pictured, is away putting a signal into the ground. Successive receiver positions moving from left to right across the pipe are shown. From a point on the extreme left of no signal (no lines of force cutting receiver antenna) to maximum signal (maximum lines of force) to no signal again on the extreme right. The curve shown in Fig. 7 relates the meter reading to the movement of the antenna across the pipe. Note the sharp rise, peak, and cut-off.

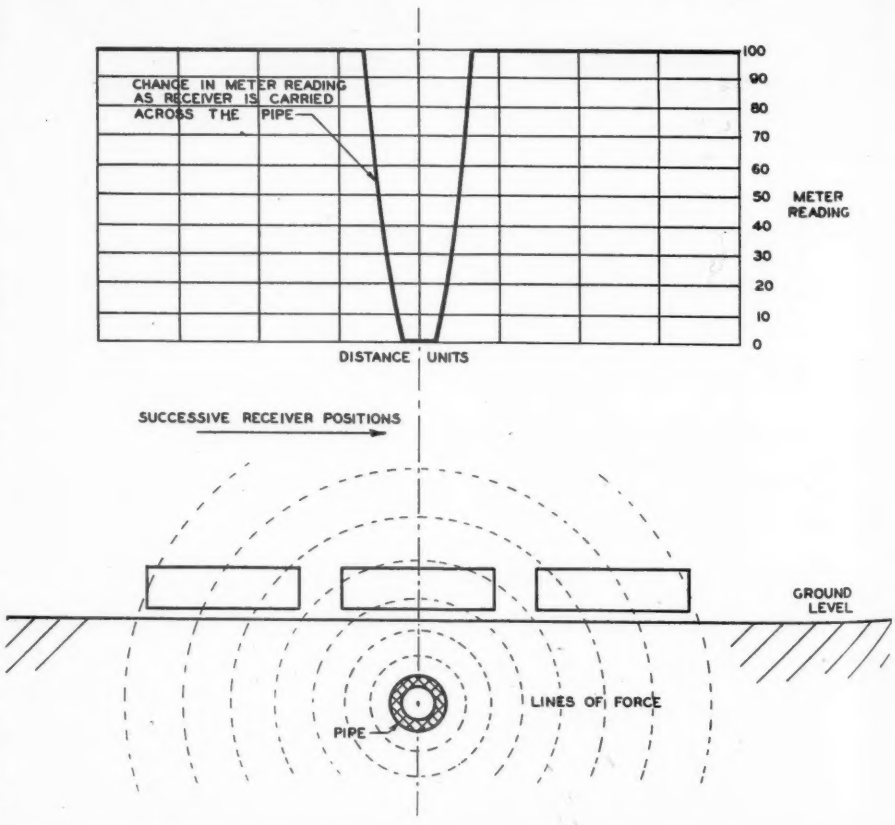
A more accurate method of pin-pointing the location of a line is the "centering" operation. The transmitter position

FIG. 8. The centering operation.

angle between the handle and pipe is as low as 30 deg. Then simply by moving 10 ft to each side of the initial location the pipe can be located again and its line determined.

The next step after locating a pipe is to trace it and establish its direction. This can be accomplished successfully with the same set-up. So long as the transmitter is over the pipe a maximum signal will be heard and by walking in such a manner that this maximum is

FIG. 9. Curve showing the change in meter reading during the centering operation.



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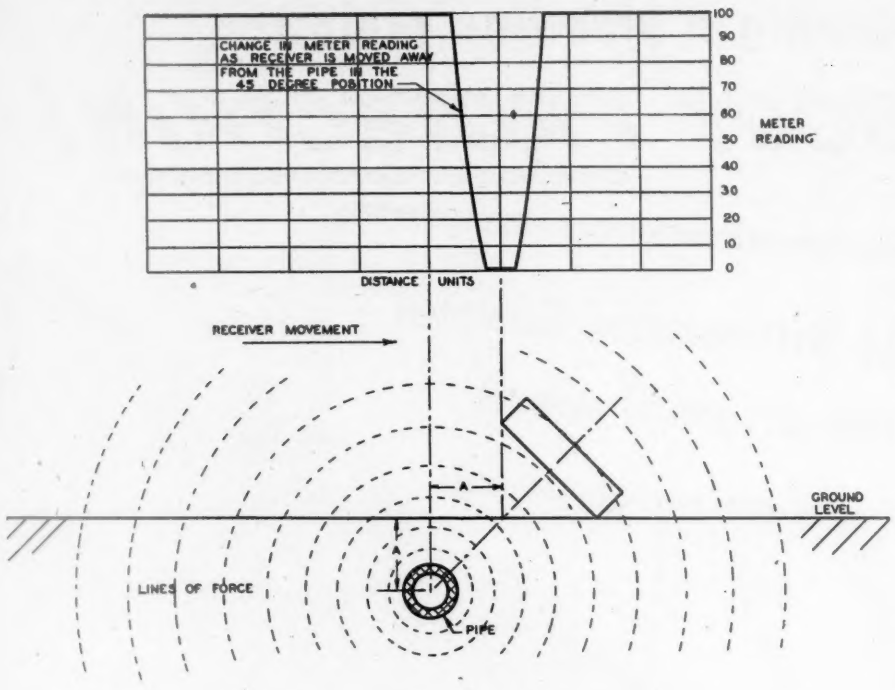


FIG. 10. Depth measurement.

remains unchanged, but the receiver is held flat as Fig. 8 shows.

Fig. 9 is used to show how the receiver is used and how the characteristic curve is radically changed. Once again we'll assume that the transmitter is away from us, energizing the pipe shown and setting up the accompanying lines of force. By moving the receiver box across the pipe and parallel to the ground, the pipe can be pin-pointed with respect to its location. When the receiver is in either the left or right position, it can be seen that a maximum number of lines of force are cutting the receiver loop and a maximum reading results.

In the center position, however, something else is involved. In that position the plane of the box is tangent to the radiated lines of force and a sharp null occurs. Electrically this takes place because those lines of force are impressed on all sides of the receiver antenna at exactly the same instant. With no time lag present, no oscillation takes place, and consequently no signal results. This will be discussed later when we talk about depth measurement. The characteristic curve for the centering operation shows that a full signal occurs all the way across the pipe with the exception of a very small null area directly over it. Actually the width of the null is less than the diameter of the pipe itself, which gives an idea of what accuracy can be obtained.

Depth measurement is the centering operation carried one step further and is diagrammed in Fig. 10. At any given angle from a vertical axis through the pipe the box can be tilted in such a way that a null will be produced. To avoid any complex formulas we chose the 45-deg position to locate the point of null. Note: Practically all locators have a device built into the receiver that shows the operator when the box is in 45-deg position. With the box held at this angle and moved through successive positions, left to right, you will hear the same type of signal as was heard during the centering: Full signal, sharp null, and full signal again. At the null point a perpendicular is dropped from the front edge of the box. Then, by measuring the distance from that point to the previously marked center point and subtracting the height of box above ground, you have left the depth of the pipe. Actually this can be simplified further by moving the box away from the pipe right at the ground level; then the horizontal distance on the ground is exactly equal to the depth of the pipe.

One problem, mentioned earlier, which comes up again and again particularly in the oil fields is that of separating closely spaced pipes.

For purposes of illustration let us assume the situation as shown in Fig. 11. At Station 2 the four pipes shown are exposed and separated by a distance of 2 in. or less. The problem is to find which pipes run through Station 1.

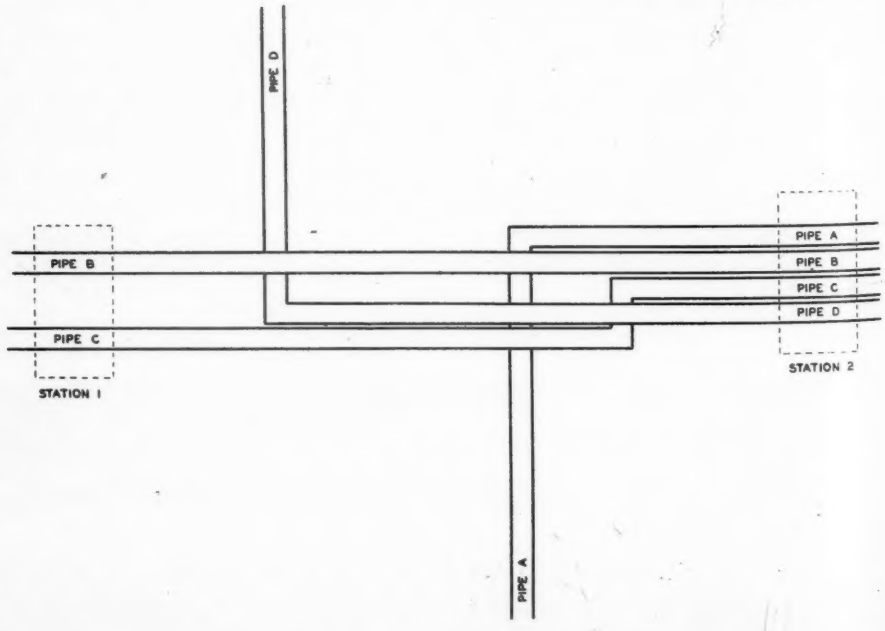
Of course normal procedure would be to place the transmitter over the pipes at Station 2 and trace by the induction method. The limitation of this procedure is readily apparent: The fact that all four lines are energized and will each carry a signal. There would be no way of distinguishing one pipe from another at Station 1.

By coupling the transmitter and one specific pipe directly with the direct connection cable it will then be possible to isolate the pipes. For instance, by tying on to pipe B at Station 2 the receiver will accurately show the position of pipe B at Station 1. Each pipe in turn could then be located in this way as there would be no spread in signal to adjacent lines.

As another problem let us assume that the two pipes B and C are exposed at Station 1 and it is desired to find out where these pipes are at Station 2. Of course the direct connection method could be used but let us examine an alternative solution.

The normal induction tracing method would still not be practical because of the danger of energizing both lines. Case 1 in Fig. 12 shows how this occurs; but suppose we orient the transmitting unit so that it is lying in a flat position over Pipe C (as in Fig. 12, Case 2). The lines of force are such that pipe

FIG. 11. A typical pipe pattern in which the proximity of the pipes to one another presents a location problem.



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7-3794

C lies in a null position with respect to the transmitter and yet pipe B is still being cut by lines of force and will carry the 100-kc signal. Then by using the centering procedure at Station 2 pipe B can be pin-pointed.

One glaring fault of the early locators was the inability to locate valves. This can be accomplished with the modern two-box locator by using the induction balance principle. After the pipe has been located and marked or staked out, the procedure is to turn the pipe locator so the longitudinal axis of the carrying handle is parallel to the pipe. The set is then tuned to the pipe by rotating the microtuner screw on the handle until a minimum signal is heard, or about 10 scale divisions on the indicator. Then when the operator walks right down the line of the main, the valve, because it represents a greater volume of metal than the set is tuned to, shows up as an increase in reading and signal strength. By this method it is possible to locate line or gate valves that may or may not have a riser and valve cap.

An entirely different procedure is used when the valve is known to have a cap or when locating curb boxes, gas drips, meter boxes, or manhole covers. In this operation the set is used on the handle but is not balanced inductively. In fact, it is intentionally thrown out of balance by rotating the microtuner screw and the result is a full signal in the phones. Then, with the transmitter down and the handle in a vertical position, the area is actually explored by moving the set so as to keep the transmitter as low to the ground as possible. Then, as soon as the transmitting antenna comes in proximity to the metal to be located, there is a shift in the frequency of the output signal. The new frequency enters the receiver and the end result is an increase in the frequency of the signal heard in the phones. In other words, the pitch of the note heard in the phones is raised and reaches a peak when the transmitter is directly over the metal object.

This analysis will not by any means solve each and every location problem that arises but it is hoped that an understanding of the basic principles may be gained from the foregoing discussion that will enable the engineer or technician to apply them to the problem at hand and achieve a successful result. *

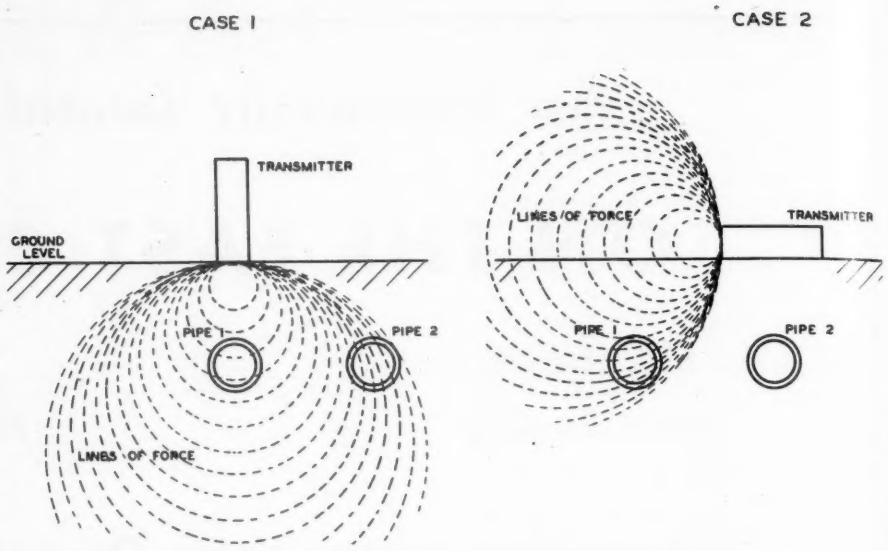

FIG. 12. Variation in transmitter positions to assist in separating parallel pipes.

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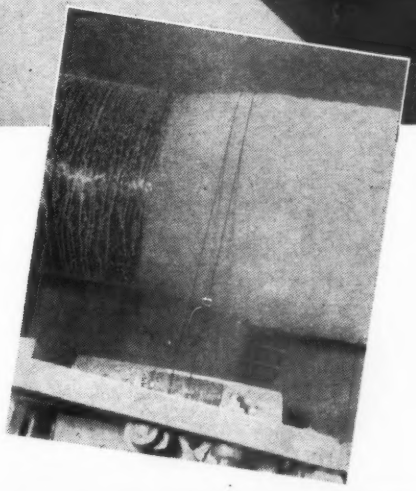

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EXCLUSIVE

How to Develop a Microwave System

After the economy of installing a system is decided upon, what are the next steps?

WILLIAM LANCASTER

IN planning a microwave communication system many objectives must be considered. Basic considerations are the need for a number of voice bands over a given area and the points of service.

To prove the economy of constructing a microwave system there should be a demand for a minimum of five voice channels. The ultimate value of a system of this type can best be realized when future requirements are studied. The cost of installing additional facilities for supervisory control and telemetering are inexpensive in comparison with the cost of constructing additional physical circuits or leasing facilities.

The construction of a microwave system may be accomplished in a number of different ways. Suppliers of microwave equipment will contract for a complete system survey, installation, line-up and even operation if desired. The other extreme is to purchase the equipment and do your own engineering, installation, and operation of the plant. Somewhere between these two extremes is the proper method to follow. A competent engineering group can lay out the desired circuit arrangement. The terminal and relay station locations can be determined from the physical locations of points of service. Using geological survey maps profile charts can be developed and approximate tower heights determined. The equipment can then be purchased on a competitive bid basis. The specifications must be worked generally so as not to exclude suppliers who manufacture equipment to operate in a given frequency range. The quantity and quality of the circuits can be specified and the method of operation given.

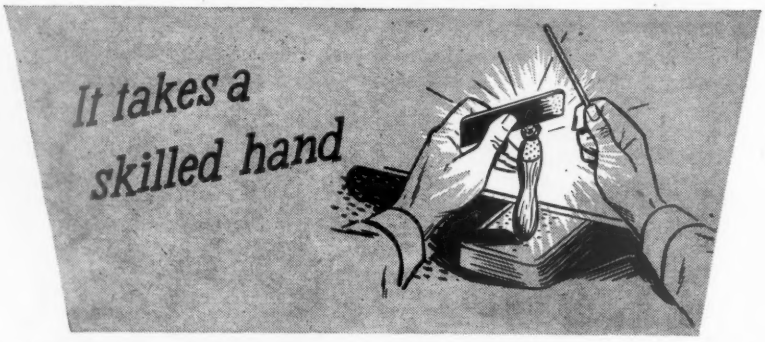
The purchase and clearing of relay sites can best be handled by the purchaser. The construction of buildings, towers and general development of these sites can be contracted by the purchaser to his specifications more economically than when a third party enters into the project. The installation, testing, and line-up of the system can best be handled by the supplier, especially when he is developing a system to a given standard.

In planning the location of relay station sites future maintenance must be studied. All-weather accessibility, availability of a reliable source of stable commercial power and right of way for drop service must be considered. The eventual overall service the system will give is largely dependent upon the engineering, planning, installation, line-up and maintenance by properly qualified personnel. The extent to which frequency space will be allotted to the industrial service will to a great extent depend upon the use we make of it and our ability properly to supervise our service.

* * *

The Author

William Lancaster is currently employed by the Sinclair Pipe Line Company developing its microwave communication and control system. He studied radio while employed with Western Union Telegraph Company, working with automatic telegraph equipment on both the cable and land line systems. In 1948 he was one of the crew that put the Western Union microwave system in operation.



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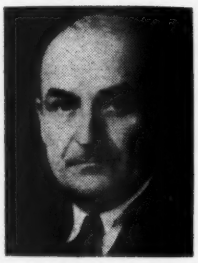
Fleet Maintenance Methods

Efficient fleet operation depends on many factors—Here is an outline of what they are

ROBERT M. HUTCHISON

The Author



Robert M. Hutchison, transportation manager and research and safety director of the Houston Natural Gas Corporation, is an alumnus of Pennsylvania State College, where he received the degree of B.S. in metallurgical engineering. He is the inventor of the "Hutchison Calculator" and the "H and H Odorizer." He is a member of Sigma Chi Fraternity, Tau Beta Pi Engineering Society, National Society of Professional Engineers, American Society of Safety Engineers, and Houston Engineers Club, having served two terms as president of the last named.

At a time when every activity, from the operation of the army to the collecting of garbage, travels on wheels, to say that automotive equipment must operate efficiently is not enough. Efforts must be made to see that it does, because it is now an established fact that the one who gets there "firstest" gets the "mostest", and that doesn't necessarily mean with the greatest speed. It means that when you start, you want to finish, and unless your transportation is dependable you very often won't even start. If this happens to the army, the fire department, the ambulance service, the garbage collecting crew, or what have you, there is usually much ado, and it generally lands on the head of the man in charge of transportation.

Having been designated "one of those things" a little more than a year ago, the writer took account of stock, talked to everyone he could meet, collected records, studied other practices, etc. In other words, he begged, borrowed, bought, and cajoled all the material that seemed to be available on the subject, and, after sifting, weeding, revising, and digesting the data at hand, he came up with what he thought was, in part, the answer to efficient fleet operation.

It is a self-evident fact that accurate records must be kept before reliable operating costs can be determined, and so the first step in the operation of a company garage is the institution of a method whereby all charges are made correctly. In the matter of allocation of spare parts to individual cars, it is well to maintain a parts department, properly balanced as to inventory, and controlled by stock symbols. The warehouseman can then keep accurate accounts and see that charges are correctly made. He can, in addition, determine when parts become obsolete, and, with proper arrangements, the parts depot will allow such items to be returned.

The process of buying parts is greatly facilitated if purchases are made with emergency orders because, in this way, no time is lost waiting for requisitions to be handled through the purchasing department. This method of purchasing can be used when buying batteries, gasoline, oil, recapping tires, seat covers, painting, and body work, et cetera.

In the maintenance of batteries, a plan has been worked out with a supplier whereby he delivers a new battery in exchange for an old one and gives credit for the unused part of the guarantee, if such exists. An efficient charger is maintained to use on all dead batteries so the garage can determine for itself whether a battery has outlived its usefulness.

In the dispensing of gasoline, it was found most advantageous to install sufficient storage to accommodate a transport load of 4000 to 5000 gal, and to use an accurate pump and meter for measuring the deliveries to the various units. By issuing a ticket each time a car is serviced, storage and consumption can be checked each morning, and the net result at the end of the month will be a close balance. Thus, with outage at a minimum, the saving effected by the purchase of transport loads will be maintained at its top level. A close record of oil consumption can also be kept on the gasoline ticket, thus assuring the charge to the proper car.

Gasoline purchases are dependent on local conditions, and therefore each fleet operator will have to decide for himself what kind he will use. It can be said, however, without prejudice to high test products, that regular gasoline will give satisfactory operating results in most cases. Much attention is being directed at present toward the use of LPG in all kinds of trucks, and many reports indicate satisfactory results. It is, therefore, quite likely that the practice will become more general as soon as more filling stations begin handling the product, if the increased demand does not cause the price to spiral, because there is also a handling hazard connected with LPG that must not be overlooked.

As for oil and lubrication, volumes have been written on the subject and much research in this field is still being carried on, so again it is up to the individual operator to outline his own program. It appears that there is a decided movement toward the increased use of detergent oils because experience has shown longer engine life and less mechanical wear from their use. It must be borne in mind, however, that great care should be exercised in changing to detergent oils after a car or truck has used non-detergent oils for any length of time. In fact, it is far better to begin the use of detergent oils when the equipment is new or has been overhauled than to swap horses in the middle of the stream. Here again the operator should be the judge.

Top capping of truck tires and full capping of passenger tires under present efficient methods is certain to pay dividends, because most of the firms can safely guarantee up to 90 per cent of new tire mileage at a cost in most cases of less than half the price of a new tire. All recapping firms will render an inspection service designed to give maximum returns from each tire, and it will pay to take advantage of it.

It is practically certain that body work and car painting can be farmed out at prices much below the cost of doing the work in the company shop. Few shops are equipped to do a high grade paint job, and there is also a time element factor in favor of the farmout. In addition, the general appearance of the fleet will be improved by having custom paint jobs done.

A good way to prolong the life of the car finish is by the use of a good automatic car washer. Water alone will not remove road film, but the use of a good detergent in an automatic washer will add much to the general appearance of a fleet and save money by prolonging painting cycles. An automatic washer likewise will reduce the time cycle, and thus pay for itself in the saving of labor.

Each shop should have a rigid mechanical inspection program and enforce it to the letter. It is good practice to combine lubrication, oil change, and inspection, if possible, because this method will reduce the number of trips each car must make to the shop, and it is also apt to be more thorough if all three are done at one time. A 1500-mile schedule has been found to give satisfactory results, when maintained.

Additional economies can be obtained in various other ways, such as:

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year to year. This can be done by draining it from each car in the spring, storing it until the following winter, and then using it to make up the antifreeze in cars that need it during the winter season. In one fleet familiar to the writer, some 450 gal of antifreeze were dispensed in this way.

Each garage should be equipped with special tools suitable for its operation. This may include a sun tester, power drills and wrenches, certain tire changing jacks, etc. The garage foreman should be charged with the responsibility of procuring such equipment.

In states having a testing law, some garages will want to do the testing on their own cars. The equipment needed is usually not very expensive, and as its use may save hours of truck time and inconvenience, each operator will do well to give serious thought to this operation.

It is highly important to keep tires properly inflated, and each operator should be charged with the responsibility of regularly checking the air pressure in the tires on the vehicle he drives. In order to remind the drivers, it is well to post a schedule of inflation pressure at the company gasoline station.

Many companies have prepared and distributed to their operators a driver's manual that covers in detail company policy, instructions to follow in case of accident, helpful suggestions for efficient operation, safe driving rules, etc. If published under the company name, the manual will probably be beneficial because employees are generally interested in their jobs and, therefore, most of them will cooperate.

Many of the large fleets have instituted courses in driver training, especially for the drivers who cover long distances and also handle heavy equipment.

A study of the driving habits of a thousand and one different people has divulged many things of inestimable value in teaching operators how to get the most out of an automobile or truck, so fleet owners no doubt will profit materially if they employ such a means for conditioning drivers.

Many methods are being used for keeping performance records of the various makes and models of cars, but, in general, most of them report cost on a per mile basis. This is done so that comparisons can be made with the records of other companies engaged in a similar business.

Some fleets use as many as 12 different forms for operating the transportation department because, in some cases, duplicate records are kept on gasoline, oil, washing and greasing, repairs, tire mileage, batteries, usage, etc., but it has been found that the use of five is sufficient to keep all records of automotive performance. These include gasoline, oil and grease, tires, battery, repairs, and miscellaneous, and they are designed so that all information pertaining to operation can be transferred from the individual record to a history card. Thus, the data for each piece of equipment can be easily reviewed at any time.

The most valuable record to the writer, however, is the one compiled monthly by the accounting department that shows the operating cost per mile of each unit accumulated over the life for the car or truck. This record is printed with the IBM machines and shows the date, the district number, the car number, the total operating cost to date, the total mileage to date, and the cost per mile in dollars.

From this record a graph is kept monthly. The cost per mile is plotted opposite the month and year, and when the points are joined by a line, the graph shows the rise and fall of the cost per mile. From this graph it is hoped that the point of diminishing returns can be determined and used as a yardstick in establishing the proper time to dispose of a car.

The record does not include depreciation because that is a fixed cost and cannot be controlled by the maintenance and operating departments, and it is, therefore, of little value in this study. The operating figures alone, however, are of value, not only as shown above but where used comparatively with the same type of cars in like service.

The figures are made available to all operators, and thus a competitive spirit is aroused. This can very easily be reflected in lower operating costs because there certainly is a satisfaction to each of us when we can show a better record than the other fellow. * * *

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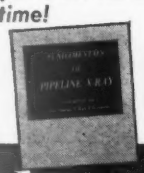

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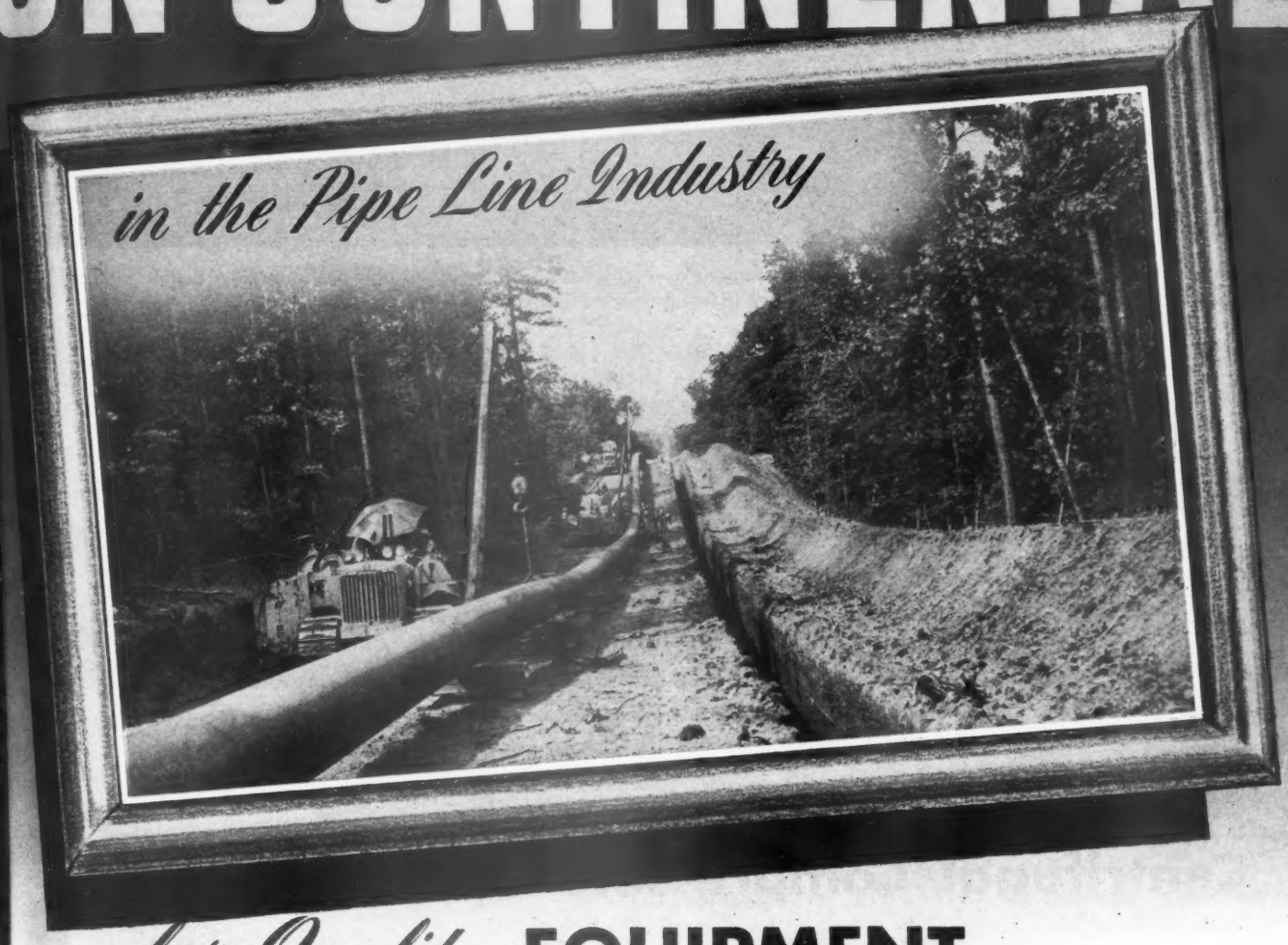

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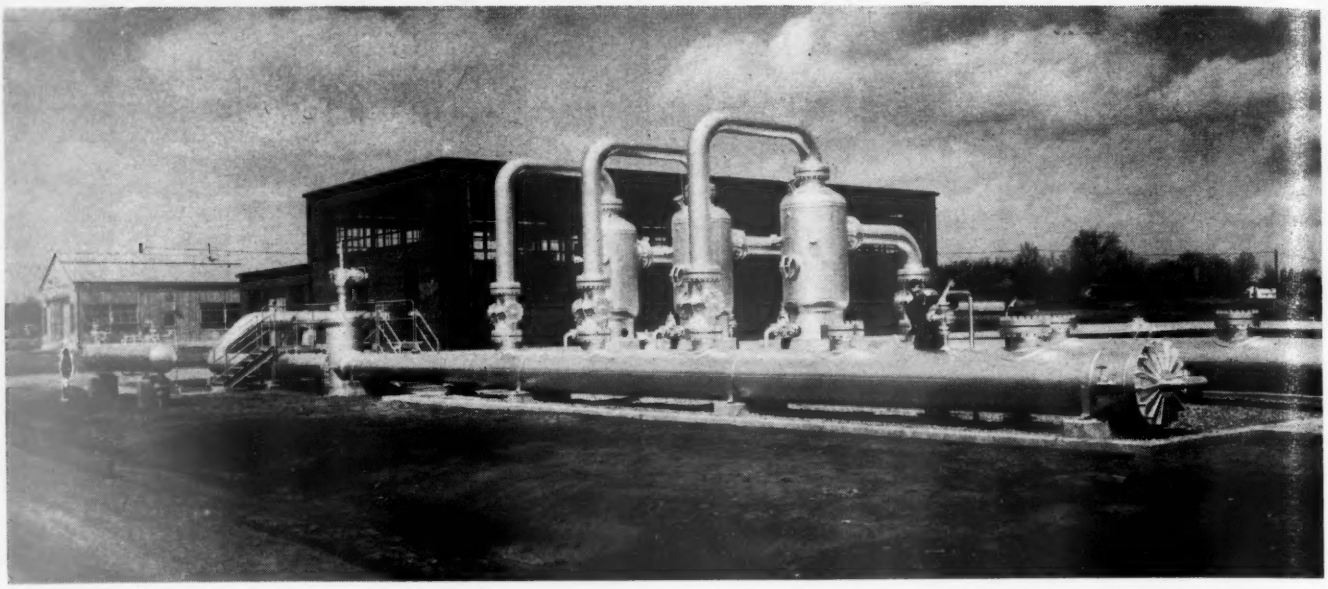


This exterior view of one of the centrifugal compressor stations on Texas Eastern's new 30-in. pipe line shows the suction header, scrubber, and compressor building. The station auxiliary building is in the left background. Location: Gladeville, Tennessee.

A close up of Texas Eastern's modern centrifugal compressor station shows the simplicity of design of the compressor building.

Centrifugal Compressors of New Design

Greater flexibility of operation obtained in Texas Eastern's new stations principally by effective use of inlet guide vanes

C. W. MARVIN

On its new system between Kosciusko, Mississippi, and Uniontown, Pennsylvania, Texas Eastern Transmission Corporation has installed electric motor driven centrifugal compressors specially designed and built to provide greater flexibility of operation than has been obtained previously with this type of equipment. As the compressors are driven by constant speed motors, this flexibility is gained principally by the effective use of inlet guide vanes.

A total of thirteen 2500-hp units have been, or are being, installed on the system. At Barton, Alabama, and Gladeville, Tennessee, the stations have been completed; at Wheelersburg and Berne, Ohio, they are under construction. Each station will have three units except Berne, which will have four.

Compressor Performance

The purpose of the new units is to make it possible to develop fully the

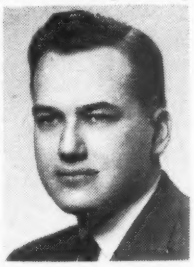
EXCLUSIVE

available power of the motors under adverse conditions, such as when a compressor unit is down. For example, a station of normal design will develop 100 per cent of the rated horsepower of each motor under normal operating conditions. By adjusting the inlet guide vanes to the "against rotation" position, however, the extra 15 per cent service factor of a motor can be developed because of the additional compression ratio developed.

Another favorable factor is that small,

The Author

Conrad William Marvin, chief of the plans and research section, engineering department, Texas Eastern Transmission Corporation, was born in Kansas City, Missouri. He received his education at the University of Kansas, receiving a BS degree in chemical engineering in 1942.



His first job was as an engineer with the U. S. Rubber Company. During World War II he served as an officer in the U. S. Air Force from April, 1943, to November, 1945, flying 36 missions in the Southwest Pacific. After the war Marvin worked as an engineer for Panhandle Eastern Pipe Line Company until May, 1947, at which time he joined Texas Eastern's engineering department.

"as built" variations from design power requirements of stations can be compensated for by adjustment of the guide vanes. The operator is thus able to pick his most effective operating point.

Guide vane adjustment also can be made to provide the most efficient use of power at any given station or group of stations, as the load can be partially shifted from one station to another.

The compressor units are designed for an initial rated capacity of 387,000,000 cu ft a day but the design is such as to allow for expansion. This expansion or increased capacity is brought about by changing impellers. Initially, low capacity impellers have been installed, having a design point from 5000 to 5500 cu ft per minute. High capacity impellers (to 10,000 cu ft per minute) can be substituted by merely changing the wheel and associated volute insert.

Fig. 1 is a characteristic performance curve of a single centrifugal compressor. It shows: (1) Limits of use of guide vanes, and (2) efficiency at which the unit will operate under given conditions. The graph reveals that in this particular case the most efficient point of operation is at 6500 cu ft per minute inlet with guide vanes in radial position, and that under such conditions the unit will develop a head of 5300 ft.

Compression ratio is computed from the equation:

$$R = \left[\beta^{\frac{n-1}{n}} + 1 \right]^{\frac{n}{n-1}}$$

$$\beta = \frac{H \times G}{53.35\ Z\ T}$$

Horsepower required at shaft of compressor is computed from the equation:

$$Hp = \frac{0.00164\ H\ Q\ G}{E} + 50$$

Where:

R = compression ratio,
H = adiabatic head, ft,
G = specific gravity of gas,
Z = compressibility factor at inlet condition,
T = suction temperature,
Q = capacity, MM cu ft per day (15.025 psi @ 60 F),
E = adiabatic efficiency,
n = ratio of specific heats of gas C_p/C_v.

Description of Compressors

The compressors are direct driven through spacer type flexible couplings by 2500-hp electric motors. As the various stations have different operating conditions, all impellers and diffusers are not identical, however, units in any one station are identical. Each compressor is of the horizontal shaft, overhung impeller, single stage, single suction type, with a 24-in. suction inlet and 24-

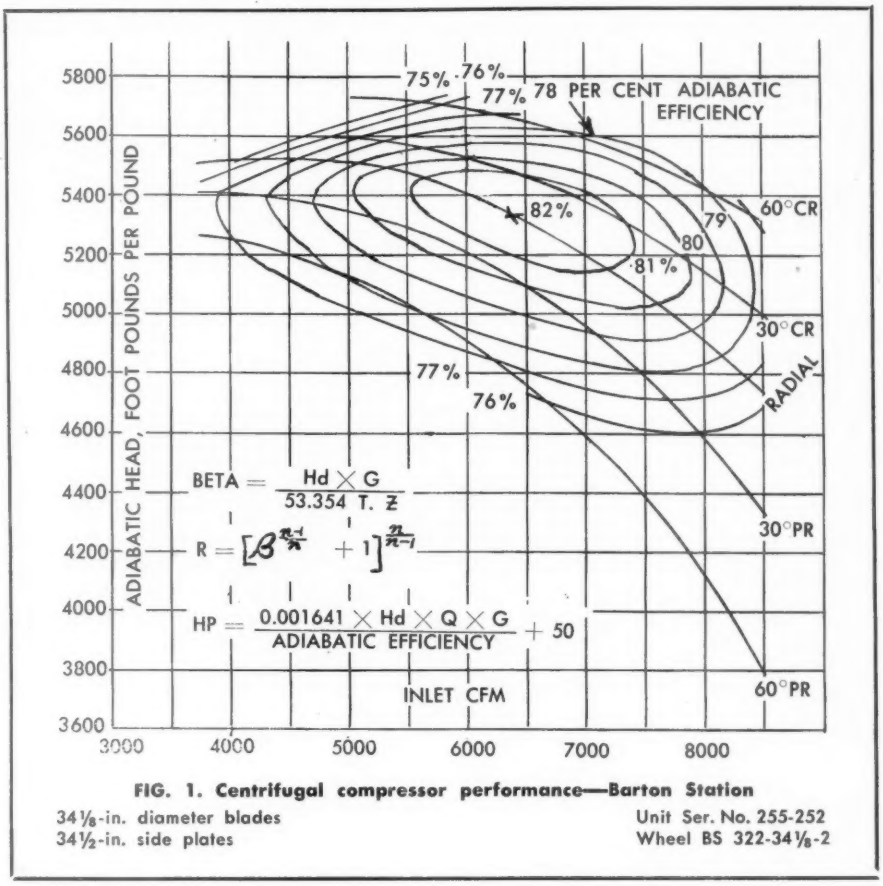


FIG. 1. Centrifugal compressor performance—Barton Station

34⅛-in. diameter blades
34½-in. side plates
Unit Ser. No. 255-252
Wheel BS 322-34⅛-2

The control boards for Texas Eastern's Gladeville, Tennessee, station are shown in this interior shot. An electric motor used to power a centrifugal compressor can be seen through the window between the control room and the compressor room.

in. discharge outlet in the same vertical plane. An end cover is provided in the casing, which permits removal of the internal parts without disturbing the main pipe connections.

The rotor is carried in two sleeve-type bearings and is axially positioned by a Kingsbury thrust element.

A feature of the compressor units is that the three basic bearings (two main bearings and one thrust bearing) and the overhung shaft are contained in a barrel that can be removed and all bearings inspected in place. To avoid downtime, a spare barrel containing these elements can be inserted while this inspection is being made.

Impellers are of the enclosed built-up type, consisting of a disk with cast-in vanes that are mounted on the shaft, and a side plate that is riveted to the vanes.

A gage cabinet opposite and facing the units gives the operator complete intelligence concerning thrust bearing temperature, low pressure lube oil, seal oil pressure, gas pressure in blower case, temperature of oil in base of blower, and lube oil temperature after cooling.

Lubricating Oil System of Compressors

Each compressor unit is equipped with a closed pressure oil system that supplies lubricating oil as well as oil for the seal.

Normally, oil is fed to the bearings and to the seal oil system by the main oil pump, a 2-in. by 1½-in. rotary displacement pump driven by 1½-hp motor. An oil filter is situated on the discharge line of the oil pump, and contains a built-in relief valve, which is set at 8 psi, and in event of clogging this allows oil to bypass filter element.

Lube and seal oil is cooled by air instead of water, a different, simplified approach to this problem. Two coolers are mounted in series. To facilitate cleaning and servicing they are piped and valved in a manner that permits either or both to be cut out of the system. The fans that provide the cooling air are direct driven by ¾-hp explosion-proof motors.

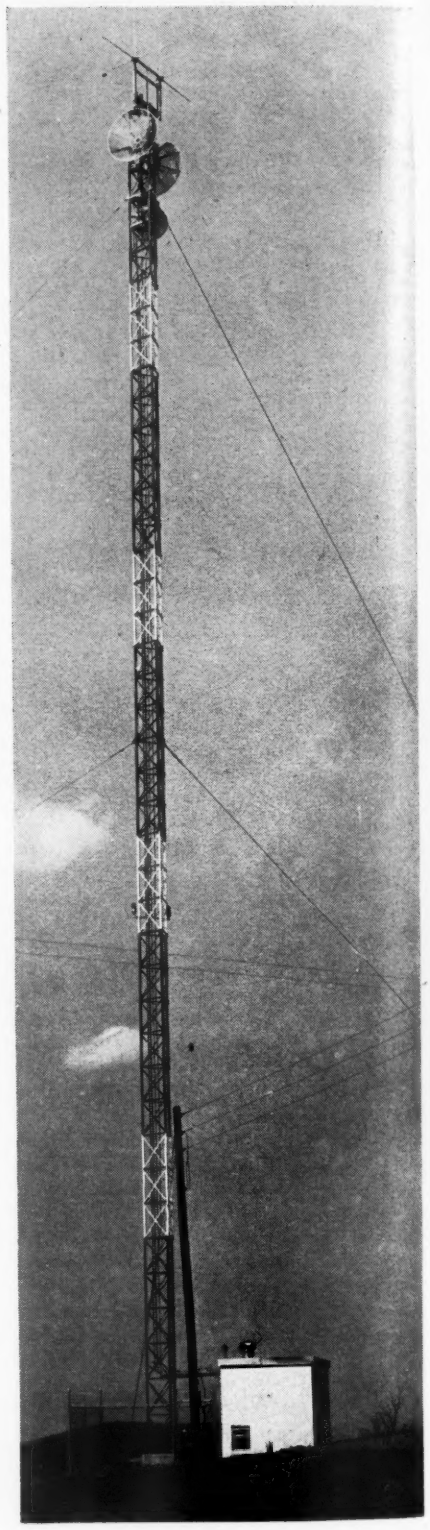
The primary oil temperature control is an automatic switch having explosion-proof enclosure. This switch regulates the oil temperature by controlling the motors of the oil cooler fans. The oil temperature is measured by a thermal bulb immersed in the oil reservoir. Normally, the switch is open and is set to close at 140 F on a temperature rise and to open at 130 F on a temperature drop. Closing the switch completes the circuit to the starters for the oil cooler fan motors, thus starting the fans and cooling the oil. Opening the switch interrupts the circuit to the starters and the fans are stopped.

In addition to this automatic control switch, two manually operated switches are situated in the circuit to control the oil cooler fan motors. These switches allow the operation of either or both fan motors provided the temperature of the oil is such that it has caused the automatic control switch to close and complete the circuit to the switches.

A secondary oil temperature control consists of a three-way valve and a sylphon bellows. Its function is to maintain at a temperature of approximately 145 F the oil entering the lubricating and seal oil systems. By means of the three-way valve the total flow, or varying portions thereof, can bypass the coolers and thereby maintain the required oil temperature. The valve is actuated by a temperature sensing bulb, through the sylphon bellows. The bulb is situated at the outlet from the coolers. Exceeding 145 F at the temperature sensing bulb results in an increase of oil passed through the coolers; a decrease in temperature produces the reverse action. The valve is equipped with a crank, which permits manual operation in case the automatic control fails.

To keep the lubricating oil in good condition it is filtered continuously. This oil flows from the oil coolers through a three-way valve to the filtering units. A lever on the three-way valve can be shifted to direct the oil through one filter or the other, as desired.

From the filters the oil is led to the bearings. In the line between the filters and the bearings a low oil pressure alarm switch is installed. When the



The microwave communication tower shown here is at Gladeville, Tennessee, along the route of Texas Eastern's new 30-in. pipe line.

This interior view shows the inside switch gear at one of Texas Eastern's centrifugal compressor stations (Gladeville, Tennessee) on the Kosciusko, Mississippi to Connellsville, Pennsylvania pipe line.

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pressure in the line declines to 4 psi the electrical contacts in the switch close to shut the unit down. When the oil pressure reaches 7 psi the contacts reopen, allowing the unit to be started again.

A low level alarm switch is mounted on the oil reservoir, and a drop in the oil level causes the switch to make contact and give an alarm.

The lubricating oil reservoir is a welded steel tank and it also serves as the pedestal for the bearings. When filled to capacity it contains approximately 238 gal of oil, but of this quantity 88 gal are diverted to the emergency tank as soon as the seal oil pump is started, so that the normal content of the main reservoir is about 150 gal. The tank is partitioned, one section being baffled and used to degasify oil returned from the seal oil leakage tank. This section has its own vent pipe; the remainder of the reservoir is vented through a separate pipe.

Sealing Oil System of Compressors

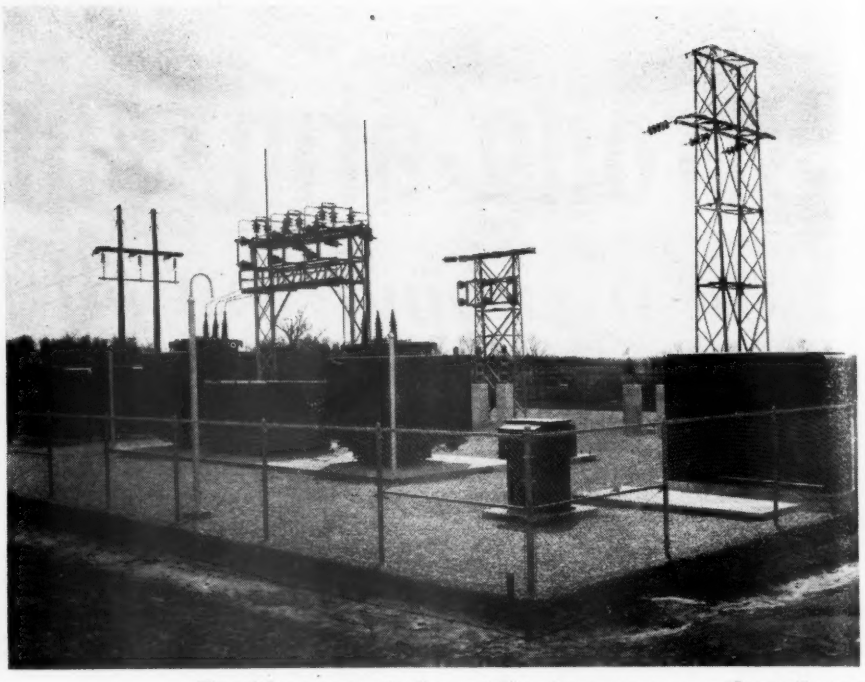
Each compressor unit has a seal that prevents gas leakage at the point where the impeller shaft emerges from the compressor casing. Essentially, the shaft seal consists of an inner and an outer seal element. The seal elements are so arranged that a chamber is formed between them for the introduction of sealing oil. By keeping the chamber filled with oil at a pressure slightly greater than the gas pressure acting on the impeller side of the seal, leakage of gas is prevented.

The seal oil supply is taken from the 10-psig branch of the lubricating oil system. This oil is boosted in pressure by the seal oil pump and is delivered directly to the seal chamber.

The oil is returned from the seal chamber to the reservoir through a regulator valve that automatically controls the seal oil pressure to maintain it 10 to 20 psig higher than the existing gas pressure. Inner and outer seal drain compartments collect the oil that leaks past the seal faces. Leakage from the outer seal is returned to the oil reservoir along with drainage from the outer sleeve and thrust bearings. Leakage from the inner seal is collected in a separate high pressure tank from which oil is returned periodically to the oil reservoir. When the outlet valve of the high pressure tank is opened, the gas pressure in the leakage tank forces the accumulated oil over into the baffled section of the oil reservoir. This section of the reservoir is vented at the point where the oil enters so that any gas carried over separates and escapes to atmosphere.

An emergency seal oil supply tank is mounted at a minimum elevation of 10 ft above the centerline of the compressors and is piped to the seal oil supply system and the gas system. This tank stores approximately 88 gal of oil, sufficient to protect the seal elements and the inner sleeve bearing for about 30 min if the unit must be shut down in event the main sealing oil supply fails. In such an emergency, the gas pressure above the oil in this tank forces oil into the seal oil chamber and creates an oil-to-gas differential pressure across the inner seal approximately equal to the head of oil between the emergency tank and the seal. The emergency tank is equipped with two liquid level controls.

The seal oil pump is a motor-driven 2-in. by 2-in. rotary displacement pump. The motor is a 7½-hp, 1750 rpm, 60-cycle, 3-phase, 220-v unit.



Electricity to operate the centrifugal compressors on Texas Eastern Transmission Corporation's 30-in. pipe line is furnished through transformer banks and sub-stations similar to the one shown above.

The compressor, motor, and valve assembly at Texas Eastern's centrifugal compressor station near Gladeville, Tennessee is shown in this interior view of the compressor room.

Motors and Sub-Stations

The prime movers are 2500-hp, 3600-rpm, 4160-v squirrel cage, induction type motors, force base ventilated, and because of this last fact no firewalls within the compressor building are necessary. Motor and compressor have a common foundation block, which is integral with the supports. A common air duct leads to all motors, and one fan unit with a standby unit supplies all the air necessary to keep the motors cool.

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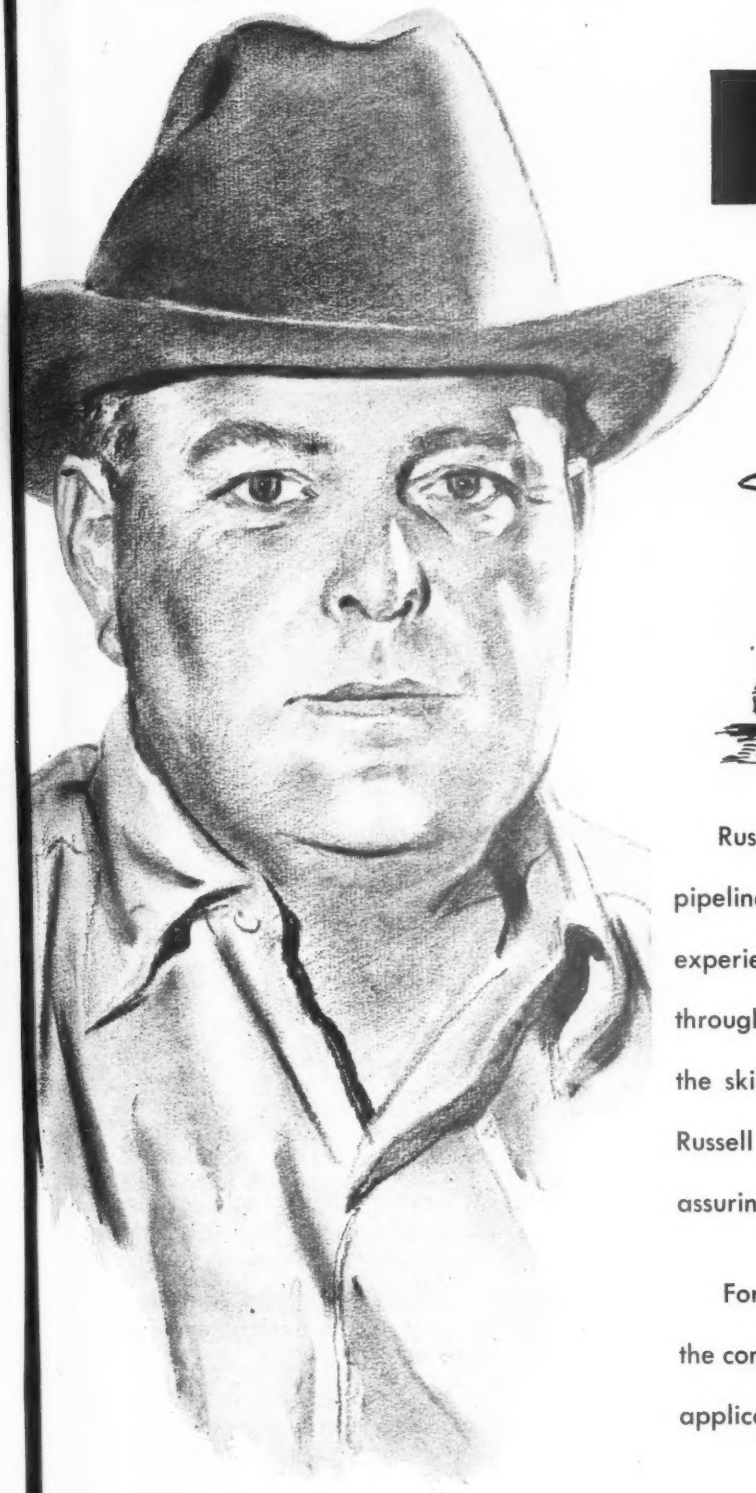

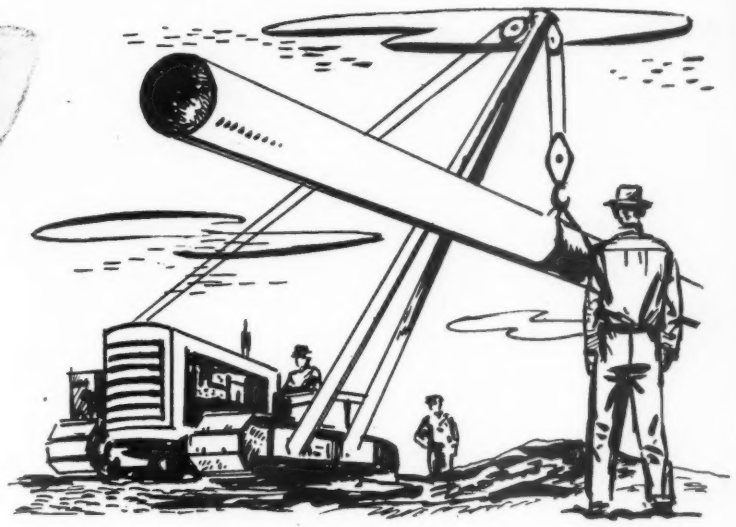

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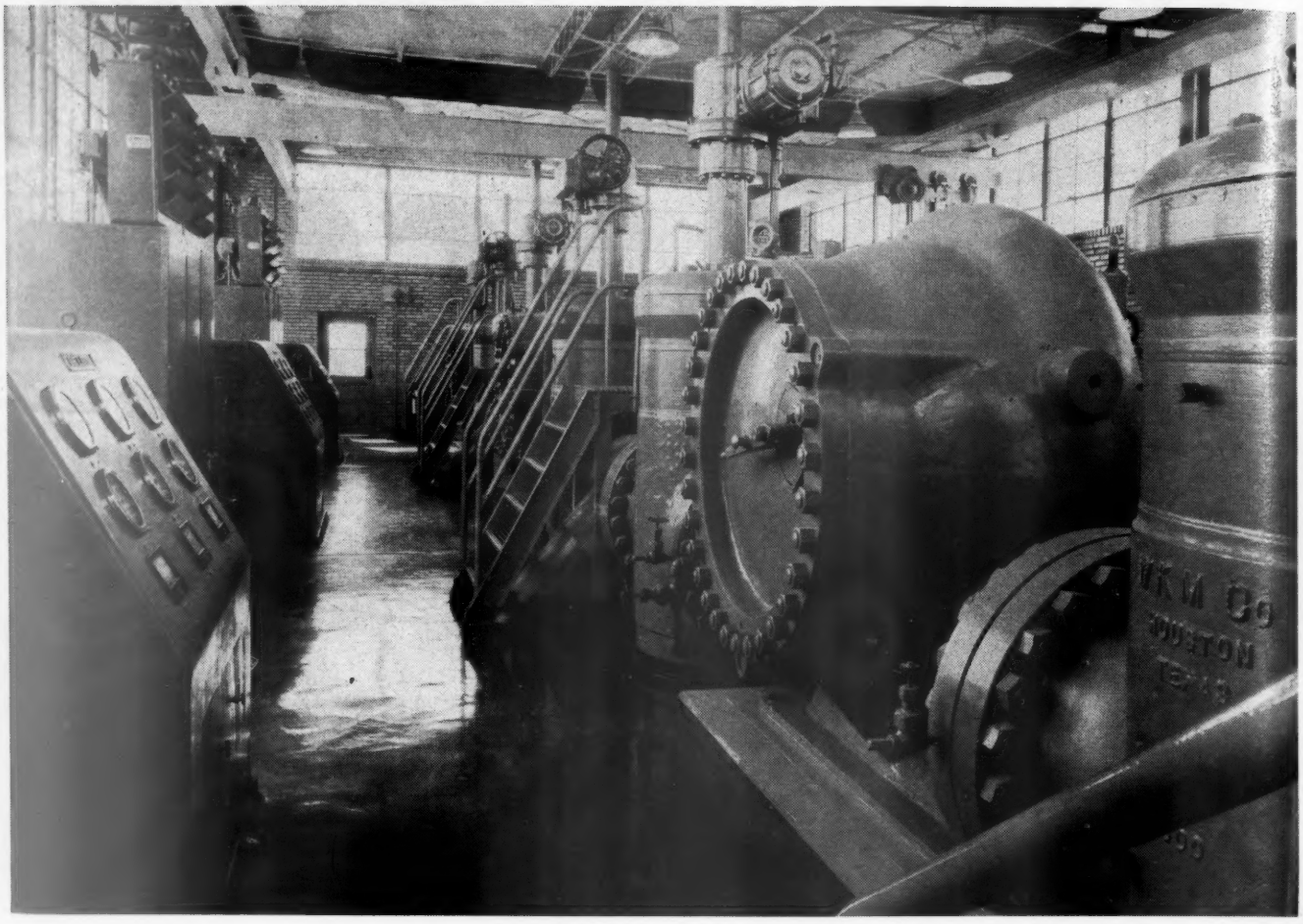

An interior view of a centrifugal station on Texas Eastern Transmission Corporation's new 30-in. pipe line. Location: Gladeville, Tennessee.

The electrical sub-station at Gladeville, which is similar to the others, consists of one 6000-kva, 3 phase 44/4.16-kv transformer with facilities available for the installation of additional capacity. The unit type sub-station contains an incoming line oil circuit breaker, which has an interrupting capacity of 150,000 kva. The full load current of the breaker is 1200 amp.

Also included in the sub-station area is a 150-kva, 3-phase, 4160-v to 120/208 v delta-Y connected auxiliary transformer. This transformer serves the lighting, motorized valves, and various pumps and motors. In the switchgear room, situated inside the main compressor building, is the reduced voltage switchgear, which controls the starting units in the sequential operation.

Unit Starting Sequence

The control set-up is such that the pressing of the start button completely starts an individual unit. The pressing of this button puts in motion the following operations in automatic sequence:

1. Permits lube oil cooling fans to operate if warranted.
2. Starts low pressure lube oil pumps that supply all bearings.
3. When this pump builds up to a specified pressure, the high pressure seal oil pump starts, which fills the seal oil system and overhead tank.
4. The case pressurizing valve opens, bypassing the main suction valve to pressure the case.
5. The motor-operated discharge valve opens when the case is fully pressured.
6. Starts the reduced voltage motor starting equipment by closing the neutral breaker, magnetizing, starting, and capacitor breaker, and, after a short period, the running breaker closes completing the reduced voltage starting.
7. Suction valve begins to open, being controlled by a contact-making ammeter that prevents overloading the unit during the starting period.

Each unit is brought on the line in this manner.

Unit Shut Down Sequence

The pressing of a stop button puts in motion the following operations in automatic sequence:

1. The unit is unloaded by closing the suction valve.
2. The main motor unit is shut down.
3. Discharge valve is closed.
4. The case is vented to atmosphere.
5. The unit then automatically resets for starting up again.

In an emergency caused by failure of certain auxiliaries, the unit automatically shuts itself down in the sequence of steps 2, 1, 3, 4, and 5 of the normal unit shut down sequence.

Station Emergency Shut down System

The emergency shut down system for the station as a whole is of great importance because of the nature of the product handled. When this emergency system goes into operation the station suction and discharge valves close simultaneously and the gas inside the station suction and discharge valves is blown down through the blowoff valve, which opens. This relieves the fire hazard by isolating the station. The emergency equipment can be activated manually by a single lever, and a device for automatically initiating the emergency system also is provided, the principle of its operation being its sensitiveness to pressure differential across the main station suction valve. Regardless of how the emergency equipment is tripped, all compressor units are shut down simultaneously. A distinct feature of the system is that the power gas supply to the valve operators and the pilot control line to the operators are under continuous pressure. Thus any rupture of the power gas supply and pilot line shows up as leakage or by activating the emergency shut down system.

Valving

The compressors are coupled with 24-in. gate valves and in-line piping. The case is pressurized before either the

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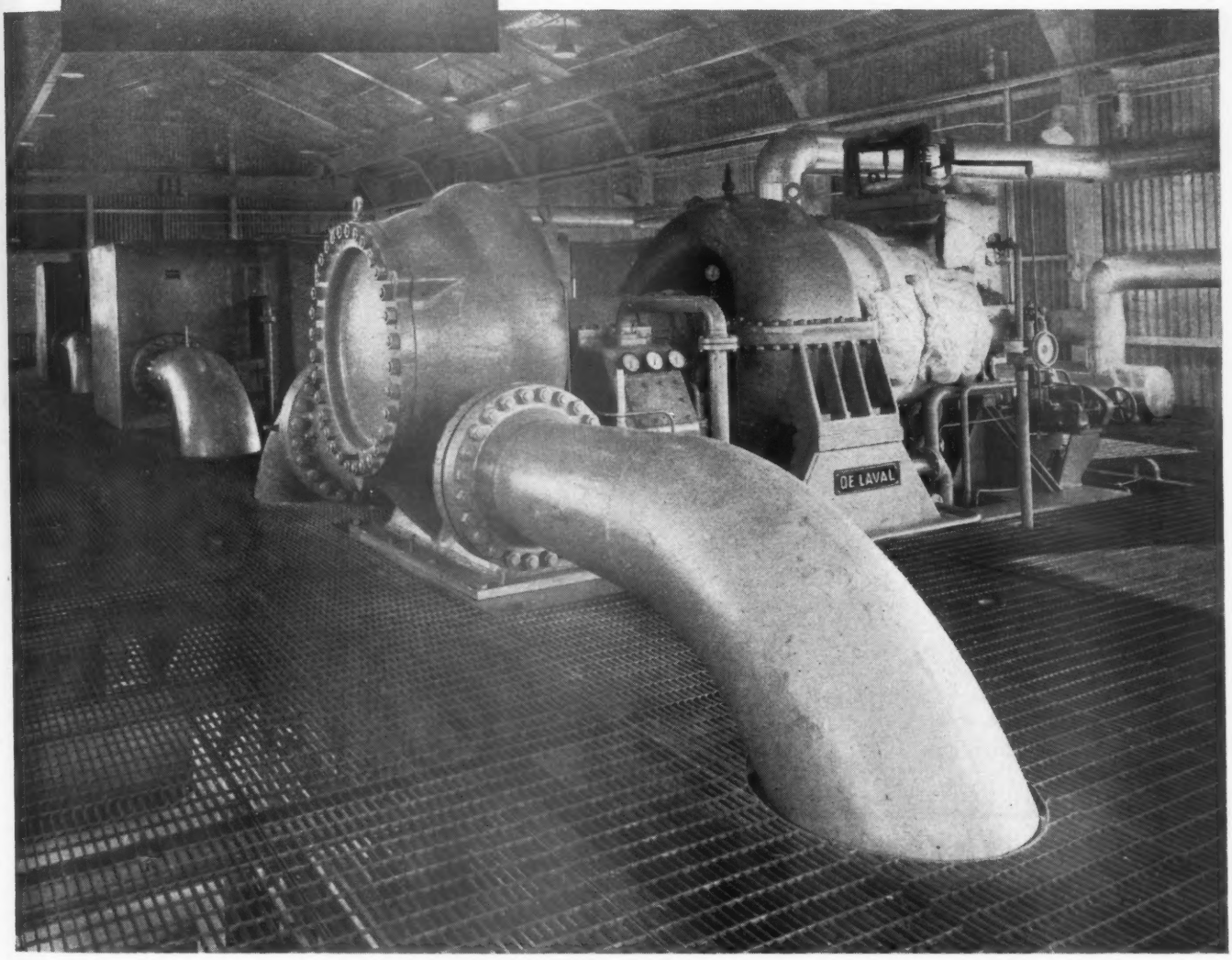

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suction or discharge valves are opened, and, as the valves are always opened under approximately equalized pressure conditions, adverse pressure differentials are eliminated.

A throttling valve is set in the suction line between the scrubber and the first compressor unit, and serves to keep the station power load from exceeding set demand.

Control Room

In the control room, which has a 4-ft by 8-ft observation window between it and the compressor room, the control desk and annunciator panel make it possible for the operator to be fully advised concerning all phases of the station operation. The control desk contains lights to show whether the individual pumping units are on or off the line, and the position of suction and discharge valves. Kilowatt-meters indicate the load on each compressor unit.

The annunciator panel contains suction and discharge pressure indicators, an indicator that shows the total electric load, recording suction and discharge pressure gages, and throttling valve controller.

Buildings

The main compressor building is 62 ft 2 in. by 76 ft 10 in., and in this building are housed the compressor units, control room, switchgear, and operational office. Construction is of brick with ample windows for lighting and a monitor through the center section for ventilation.

The auxiliary building is 36 ft 8 in. by 32 ft 8 in. In this structure are the machine shop, storage facilities, starting air compressors, emergency generator, and the station chief's office.

Discharge air from the motors is circulated through underfloor ducts to provide heat for the compressor room. The ducts are of concrete construction instead of metal to give added support to the floor on which heavy materials and machinery must be moved about. The control room is the only part of the building that has heating provisions other than this; here an electric heating unit provided.

Scrubbers

The dry, dust scrubbers at the new stations, although of the same make as some on the older system, are of different design. The improvement is in the larger conical dust recovery section, giving, of course, greater dust collecting capacity and easier blow down. Also, the dust tanks are vertical instead of horizontal.

Microwave

The microwave communications system is designed to take advantage of the flexibility of the stations. Supervisory and telemetering controls provide for the following: (1) Party line gas dispatching channel; (2) four voice channels for party and division administration and (3) VHF channel for communication with mobile units. Normally, the station power will supply 5 kva to operate the microwave system, but should power fail the emergency generator will provide the required power to prevent an interruption in communications.

General

The initial design capacity of the system is 387,000,000 cu ft a day at maximum working pressure of 935 psi. Ultimate expansion up to 587,000,000 cu ft can be accomplished by the addition of horsepower at existing stations and the construction of intermediate stations.

In designing these new stations the goal has been for simplicity, and is evident from the above discussion, particularly with reference to valving, design of the centrifugal compressor, and piping, the last being entirely aboveground and readily accessible.

The contractor for construction of the stations was Brown and Root of Houston, Texas. * * *

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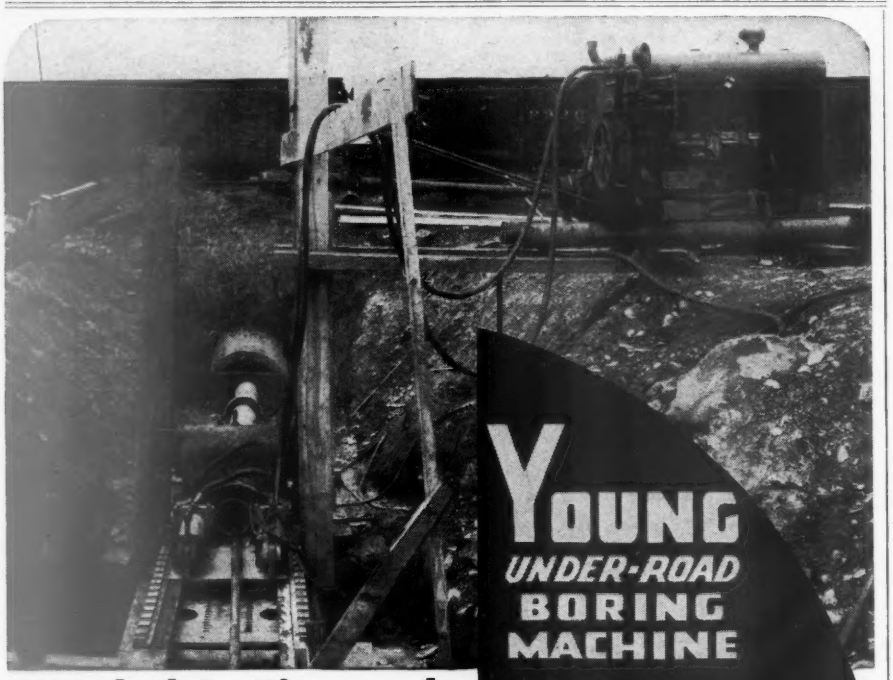

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Gaviota marine terminal. Lower site—pump house, conduit, loading rack, etc.

P 615.322

Interpreting X-Ray Radiographs of Welds

A discussion of weld effects and how they are disclosed by X-ray inspection

E. M. GREVE

INTERPRETATION of X-ray radiographs of pipe line welds is not a simple process that can be carried on by any neophyte with the aid of an elementary instruction book. It appears, indeed, that the only way in which an engineer can learn to define what he finds on the film in terms of weld condition is to acquire actual experience in relating the pecularities of the X-ray image with the structural characteristics that cause them. Although practice is necessary to ultimate expertness, however, there is no doubt that the engineer about to make his initial foray into the field of X-ray inspection can make the way a little easier and quicker by first apprising himself of the experiences of others.

That is the main purpose of this presentation. It is an account not only of the techniques employed in the weld inspection of a sizable section of 12-in. line, but of the difficulties that such a program imposes and the steps that were taken to overcome these difficulties. It includes an elementary discussion of weld effects and how they are disclosed by X-ray inspection. The commoner types of defect and their equivalent radiographic indications are treated separately, described in simple terms, and illustrated by actual reproduction of the negatives. The whole is in effect a work report that should be of interest to welders as well as supervising engineers.

Tide Water Associated Oil Company, late in 1950, installed a dual 12-in. submarine line at its Gaviota, California, terminal and this line was the subject of the inspection here described. It consisted of some 2400 ft of dual off-shore loading and unloading lines with an additional 400 ft from shore contact to the manifolding system. A contract was let[1] for the radiographic inspection of field girth welds, and the entire operation was under the direction of Frank E. Coyle, superintendent of Southern division pipe line department, and assistant superintendent, W. A. Davidson. Field engineer in immediate charge of the field work was B. R. Swanson, and welding inspectors were the author and Jack Spaulding.

[1]To Richardson X-Ray Service, Los Angeles.

EXCLUSIVE

Complete circumferential radiographs were made on each weld except for tie-in welds, making a total of 122 exposures. The system followed was to radiograph the welds in six 900-ft sections as the submarine line was strung out for pulling. The pipe was nominal 12-in., 65.42-lb material of ½-in. wall thickness, delivered mostly in 45-ft joints. In addition to the initial welds, all weld repairs were radiographed. The record shows that 29 exposures were made for this purpose, and that three of the reweld jobs were also radiographed.

On the basis of bids submitted and in consideration of all the circumstances in this particular set-up, X-ray examination was decided upon. It seemed to offer a more speedy completion of the

total operation with faster pickup of welds and repairs when necessary.

Each radiograph required about 10 minutes exposure time as compared with 30 to 45 minutes with the largest amounts of radium, and it was felt that the X-ray also promised a sharp, more easily read image with the maximum of safety to the operator. It took one portable X-ray unit working 10 days and an auxiliary unit working two additional days to finish the project. This included a full day of travel time from Los Angeles, and if that be deducted, the actual elapsed on-the-job time is 11 days for a total of 154 exposures, or 14 exposures a day.

This is a little slower time than is normally achieved on such an inspection, but it is understandable in view of the necessity of frequent moves for the convenience of the welders and the intrusion of some bad weather. Part of this lost time might have been saved by making all six strings up with the root pass or hot pass only, following this from one end with the final pass and then bringing the X-ray equipment into play. An effort was made to follow such a routine as closely as possible, but because of limited working space and the contractor's disposition of his men, it could not be carried on all the way through the operation. The highest number of welds radiographed in one day was 18, and it was the estimation of the X-ray company that with one unit they might complete 15 exposures a day plus any retakes that might be needed. The 14 average is thus not too far below expectancy.

The first real problem encountered was the large number of repairs disclosed by the radiograph. Of the initial 10 welds, 6 required repairing, and one showed a distinct hi-lo. The next 10 on the same basis of interpretation needed 6 repair operations. This promoted a conference in which the X-ray company representative, the contractor's supervisor, and Tide Water Associated's field engineer reread the specifications very analytically and looked into the entire problem with what is commonly known as a "zealous eye."

It was thought standards of acceptability might be unnecessarily stringent, or that interpretations were too rigorous. After a full examination of all the facts, it was discovered that the line pipe being used showed considerable variation in wall thickness. This tended to show up in the radiographs just like a misalignment. It was thus agreed to discount doubtful misalignment and weld reinforcing sleeves on those joints that were obviously not properly aligned. When the radiographs were interpreted again on this basis, three of the repair jobs formerly thought to be necessary on the first 20 welds were no longer required. A further change in the specifications was to clarify the "lack of penetration" clause, making barely discernible lack of penetration acceptable.

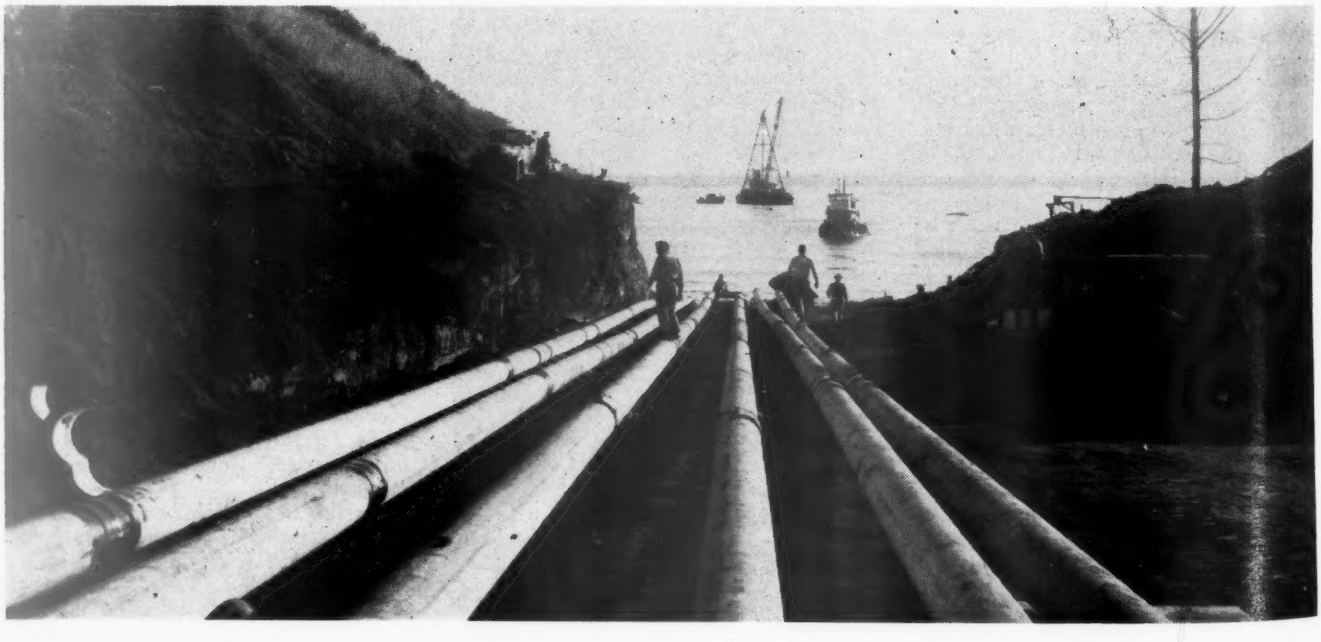
The contractor was naturally concerned with the number of welds that were being rejected, and called for expert advice on the quality of the welding rod that was being used. The rod was determined to be all that was required, but the expert suggested that much of the trouble might be dissipated if certain welders were to stop welding downhill and come up with the bead. This idea stemmed very logically from the fact that fewer repairs were needed in the uphill welds so far completed. Some of the welders weren't so good at the uphill welding technique, and after a few attempts reverted to the downhill process or gave up altogether.

It is worthy of mention in this connection that uphill welding on pipe is rapidly becoming the approved method. Questioning the welders on the subject discloses the fact that a number of companies demand uphill welding, and most schools teach it as the preferred type. Its advantage lies in better control of the molten puddle, more metal deposited per pass, and better penetration. Downhill welding, on the other hand, does not give such satisfactory penetration or afford adequate control of the puddle. It is customary to drag the hot pass or stringer bead in going downhill, and to complete the filler and wash passes uphill.

The Author

Elmo M. Greve received a BS degree in mechanical engineering from California State Polytechnic College in 1950, having specialized in welding engineering. He previously attended the University of California before entering the armed forces. He served four years as an officer in the Antiaircraft Artillery, 18 months of which were in the South Pacific. At present he is employed by Tide Water Associated Oil Company, Southern California pipe line department, as field engineer. His first work with Associated Oil Company was as machinist helper in 1941. Over a period of five years of interrupted service he has served as estimator, assistant foreman, and foreman for the Associated both in the San Joaquin Valley pipe line department and the present department. He was transferred to the Southern California pipe line department about a year and a half ago at the start of construction on Associated's Gaviota Marine Terminal.

Submarine line south of railroad trestle prior to launching.



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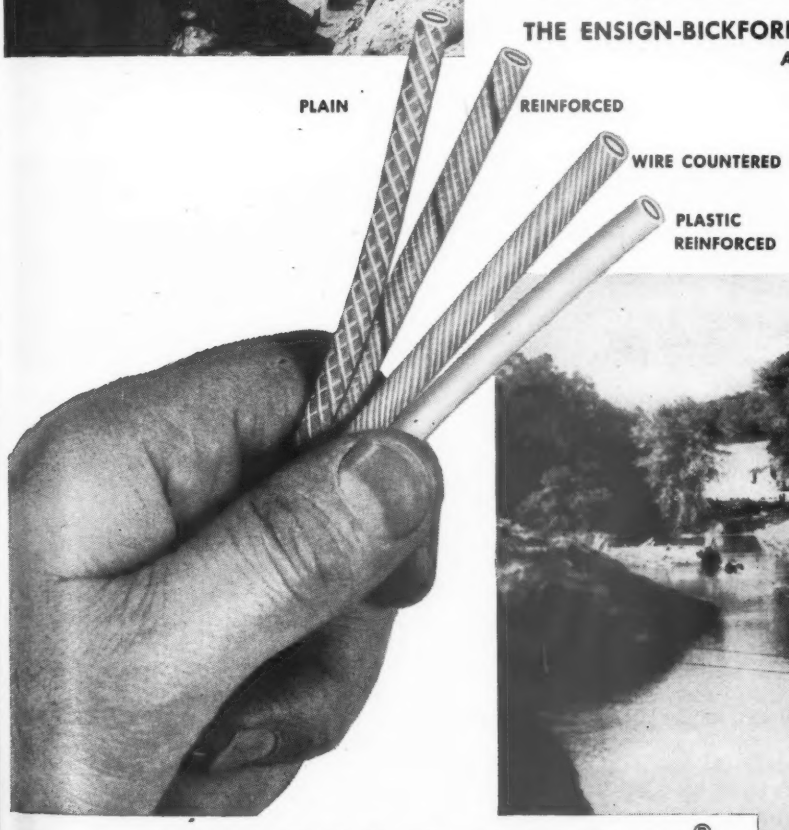

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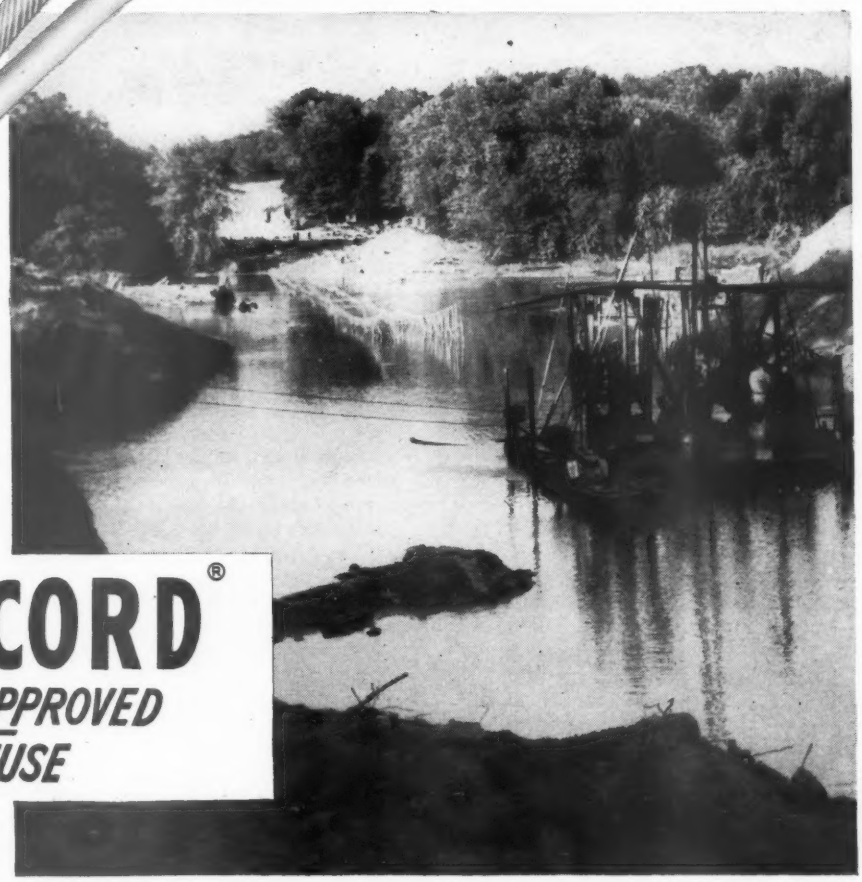

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PP-6

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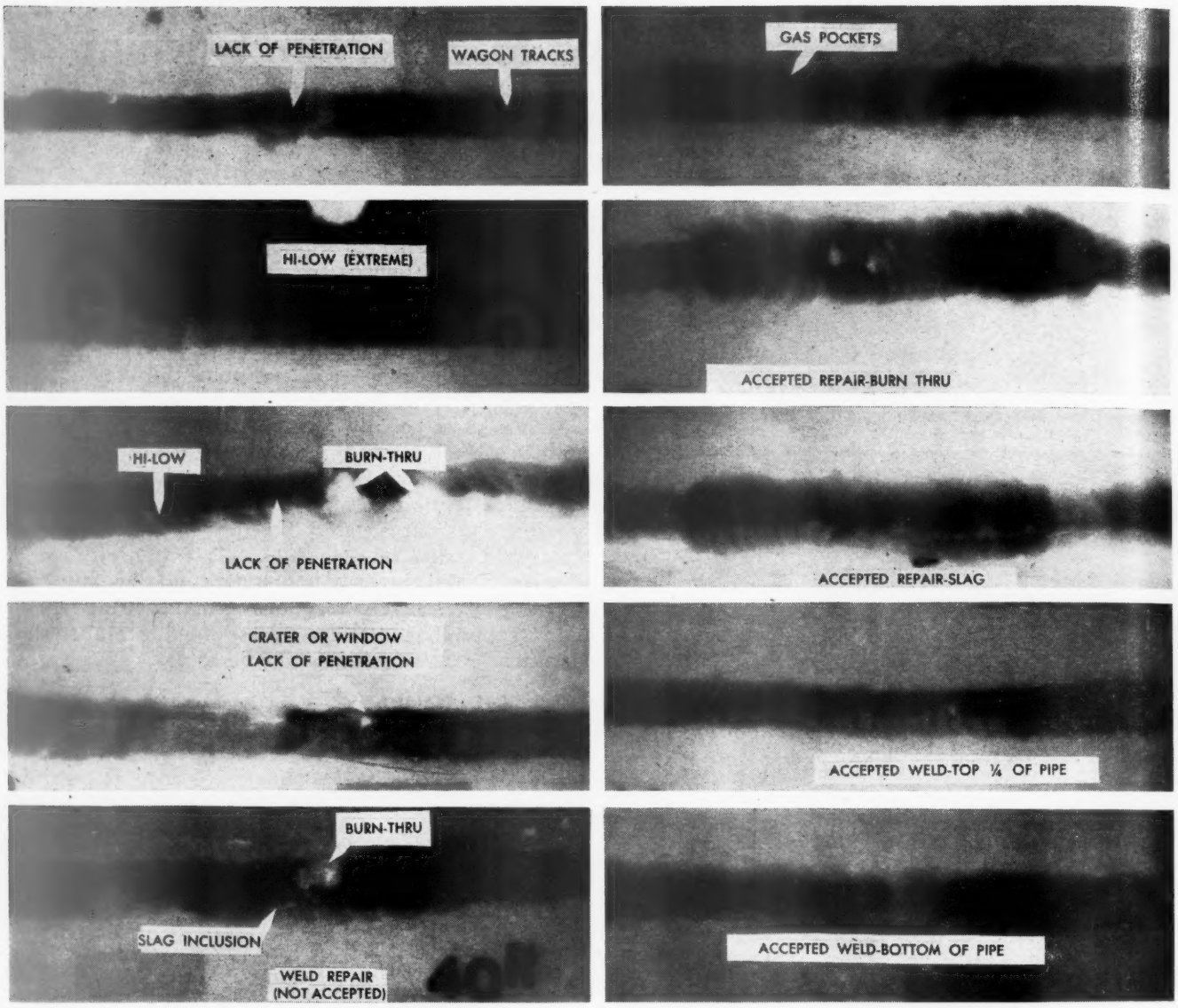

Positive prints made of X-ray radiograph negatives with interpretation of showings.

Another problem of consequence arose from the pipe itself. As already indicated, the pipe lacked uniformity of wall thickness, and although every effort was made to compensate for this condition, the X-rays still showed hi-lo's.

Considerable time was lost in sorting the non-uniform joints and trying to match thin sections with thin, and thick sections with thick. Because of these thickness variations, the pipe ends when placed together produced irregular depths of root face. This made it difficult to obtain full penetration with the stringer bead as some root faces were 3/16 in. wide and others faded away to a feather edge. This, and the presence of some bad nicks in the pipe ends, made it necessary to grind much of the pipe by hand on the job in order to provide better welding edges.

Trouble developed also with pipe bevels. The bevel angle was 30 deg, and it was concluded after some experience that a 35-deg angle would have been much more suitable. The removal of slag from stringer bead edges in the exceedingly narrow openings presented considerable difficulty. This slag showed in the radiographs as "wagon tracks." The condition was relieved by using ice picks to get into the edges, and then wire brushing or gouging with an air tool.

In general, the welding on the submarine line was of good quality. Two of the welders on this job had formerly been employed on a big 30-in. gas line by another contractor, and most of the others were men with enough of the right kind of training and experience. For most of them, however, it was the first job on which all welds were X-rayed, and they were greatly interested in using the results of the radiographs to improve their own techniques.

After reviewing the specifications with the welders, explaining to them the limiting factors, and outlining the quality of the work demanded, a definite improvement was noticeable. This is borne out by the fact that after the first 20 welds, which were made within 24 hr of the start, only 17 welds out of 102, or approximately 17 per cent required repairs, whereas more than 50 per cent of the initial 20 had to be rewelded. Most of these repairs were burn-through on the bottom of the pipe or slag inclusions.

The occurrence of so many burn-throughs on the bottom raised the question of whether or not it is advisable to make repairs in a small area that is not too deep. Repairs were made by flame-cutting or chipping the weld out, leaving sufficient space on either side of the defect to gradually build up to the surface. When flame-cutting was employed, care had to be taken to keep the stringer bead from cracking. It was the opinion of several of the engineers and inspectors that when welding a small area like a burn-through, there is created a center in which locked-in or cooling stresses are of such severe intensity that they may very well create a point of excessive weakness in the

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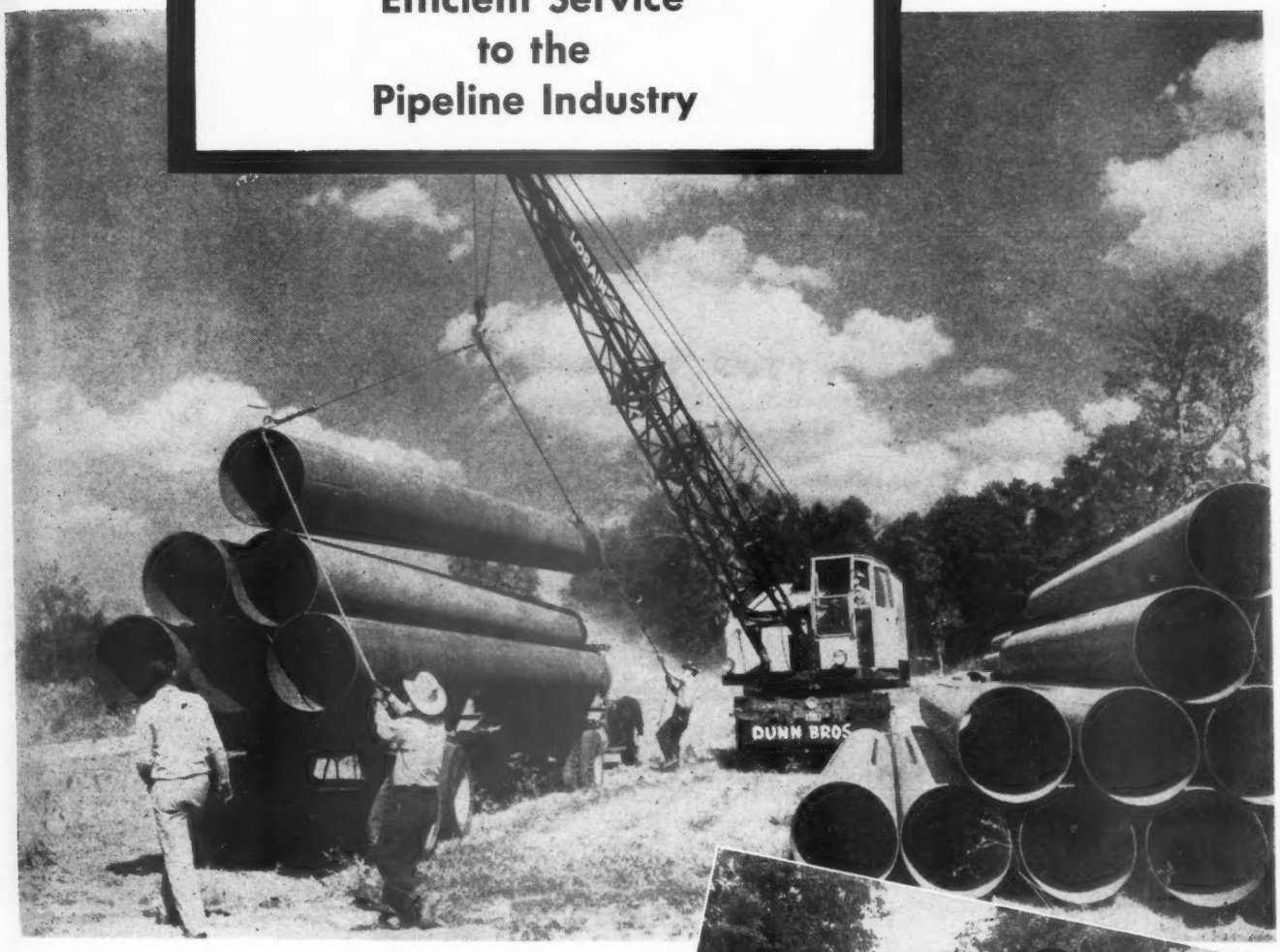

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line. For this reason, unless the burn-through crater was deep and long as shown by the X-rays, no attempt was made to repair it.

Slag inclusions were the cause of most repairs. As already noted, this could be at least partly attributed to the low angle of the bevel, and could probably be overcome by increasing the latter slightly. Following are the types of defect noted and the number of repairs occasioned by each type:

Slag inclusions	21 repairs
Burn-through	11 repairs
Lack of penetration	5 repairs
Gas pockets	3 repairs

Accompanying this article are several positive prints made from X-ray radiograph negatives taken on the job and showing our interpretation of weld defects, acceptable welds, and acceptable weld repairs. Arrows indicate specific types of defect, although in most cases there are several varieties to be seen on each film. Black and white in these prints, of course, are reverse to the way in which they appear on the X-ray radiograph film. As a further aid to understanding of the method of diagnosis, the succeeding paragraphs contain definitions of the defects in actuality and as they appear on the X-ray film.

Slag Inclusions

Slag or non-metallic inclusions in a weld, being of less dense material than the main body, show up in the radiograph as dark, irregular shapes. It will be noted on the accompanying radiographs that a certain form of slag inclusion is designated as "wagon tracks." This is the field name for the phenomenon. Slag inclusions result when the welding technique does not allow the electrode coatings to float to the surface where they may be removed or when the coating is not properly removed after each pass. Wagon tracks appear as two parallel straight lines, and in most instances on this job were caused by failure to completely remove slag on the root or hot pass. As before mentioned, this was partly attributed to the low bevel angle on the pipe ends.

Burn-Through

Burn-through appears on the radiograph usually as a uniformly oval shaped dark area with a lightness about its periphery. It causes a shrinkage crater that cuts down on weld thickness and occurs mainly when the welder is operating in the overhead position and the molten metal falls away from the working area. It is thus the effect of improper welding technique.

Lack of Penetration

The radiograph shows lack of penetration as a dark line along the root opening. It is caused by the filler material not fusing to the parent metal for the full depth of the root opening. This failure may be traced to several difficult circumstances, but ordinarily is believed to be largely the result of working with too small a root opening, too large a filler rod, or too low a machine setting. A second demonstration of lack of penetration showed in the radiograph in a few instances as what the operators call "a window." This appears as a dark triangular area. The defect is caused by a break in the arc during the progress of the root pass, and failure to obtain full penetration when starting again, thus leaving a crevice that is not penetrated on the filler pass.

Gas Pockets

Gas pockets, or porosity in a weld, are indicated in the radiograph as small, round, dark spots. The images may be fine or coarse, widely scattered, or closely grouped. They represent globular voids caused by the formation of gases during the cooling of the weld metal, and are largely attributable to excessive welding heats or incorrect manipulation of the welding arc.

These observations, made in a series of actual tests on a line in the field, will, we hope, be helpful to others who find themselves faced with a similar necessity. There can be no questioning the virtue of radiographic X-ray inspection of pipe line welds. The process is scientifically sound and the results when properly interpreted are of inestimable value as a gage of work quality. All that is necessary to realize the full benefit of X-ray inspection is to become sufficiently familiar, by actual application, with the pertinent radiographic phenomena and their meanings. * * *

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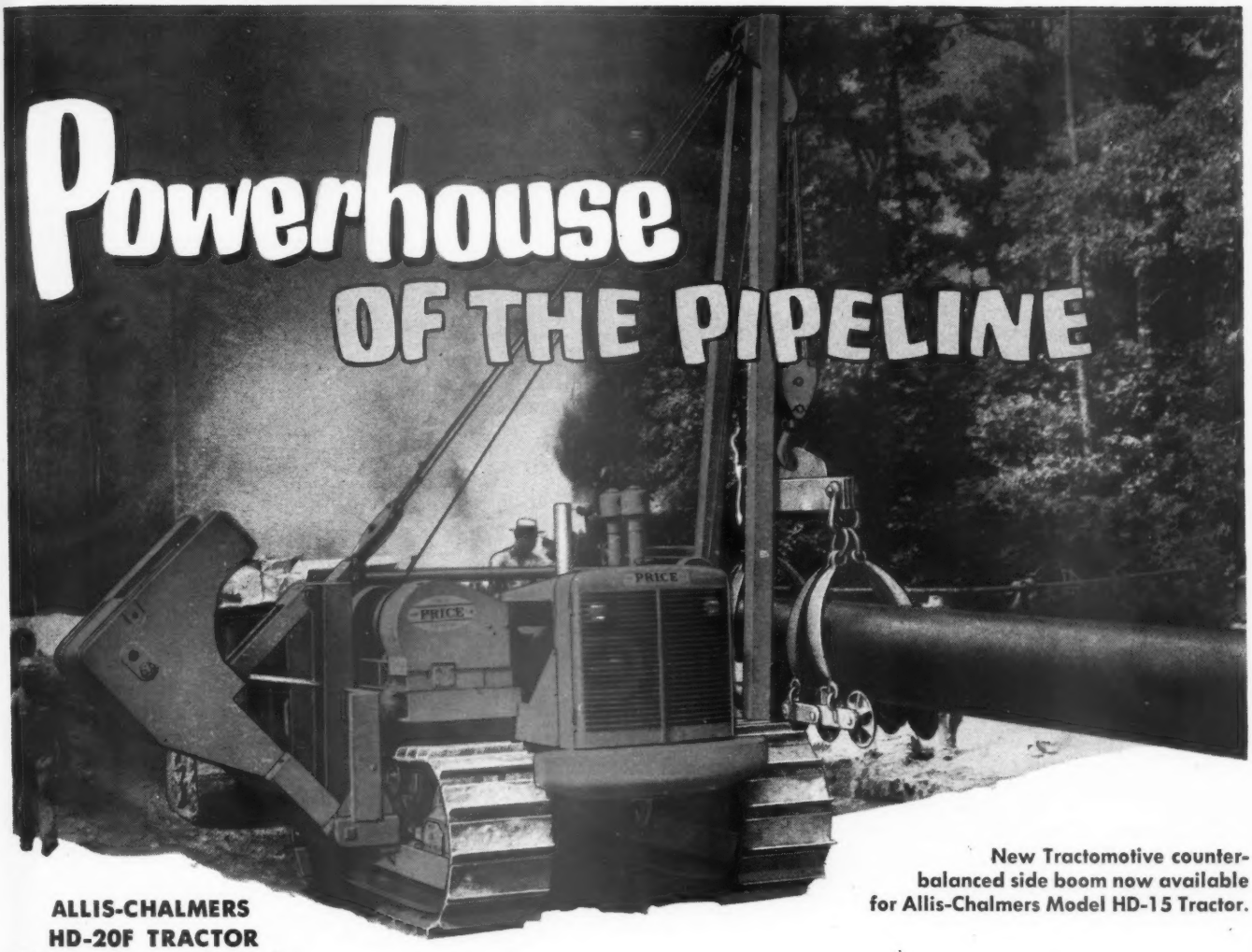

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Allis-Chalmers HD-20 Torque Converter Tractor with Tractomotive Side Boom

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Suspension bridge crossing of the Pearl River on 68-mile section of 30-in. line between McComb, Mississippi, compressor station site and Jackson, Mississippi. The structure comprises one 500-ft span designed for the 30-in. pipe. Another crossing of the same river north of Jackson is of the multiple underwater type.

Expansion Program Increases Flexibility

United Gas pipe line is spending $181,000,000 for new construction to enable it better to serve the Gulf South

DON R. PFLUG

A LOOK back over the past 12 months of oil and gas pipe line construction brings into sharp focus the fact that one of the outstanding single projects of the period was the construction program launched in 1951 by United Gas Pipe Line Company, which will be brought to final completion this summer. Reports on segments of United Gas' expansion program have been published in *The Petroleum Engineer* and in this article the editors are primarily interested in presenting a broad, overall description of the entire project with some special emphasis on the compressor station phase of the project.

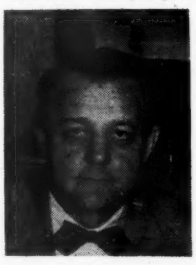
The significance of the United Gas pipe line construction program is not found primarily in its size, although it is the largest pipe line construction activity undertaken by a natural gas company during the last 12 months; nor does it fall into the category of a transcontinental pipelining project, despite the fact that the overall construction job actually involves the laying of approximately 1700 miles of gathering, distribution, and transmission natural gas lines, building of new compressor stations, dehydration plants, and other facilities. Cost of the work, when completed, will be about $181,000,000.

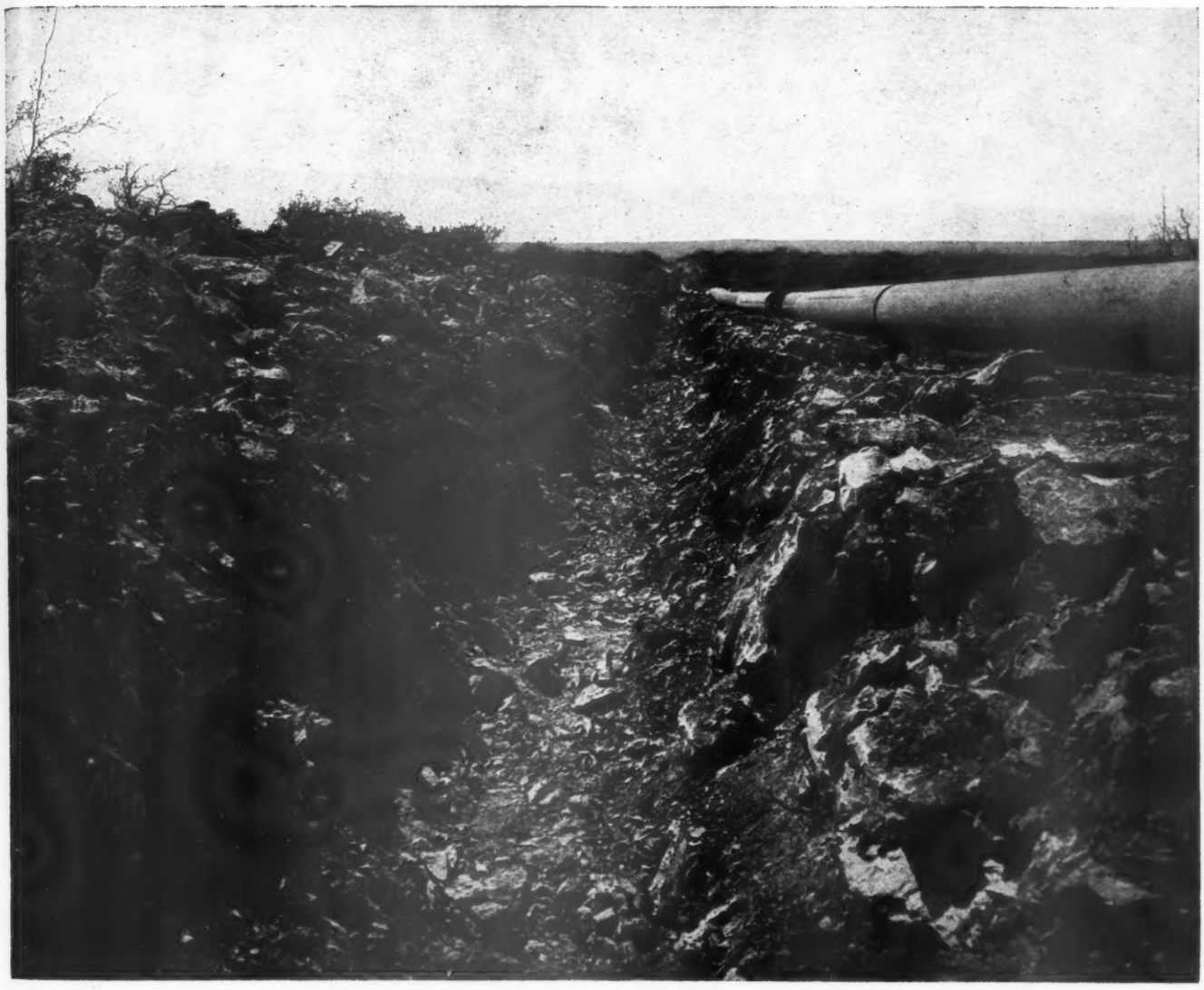
The real significance of this expansion and construction program is that all new pipe line mileage is within the boundaries of a five-state area, which United Gas calls the Gulf South. Actually the new construction gives evidence of United Gas' aim, and ability, to meet and keep ahead of the natural gas requirements of the area that the company considers its primary responsibil-

EXCLUSIVE

The Author

D. R. Pflug, chief engineer, United Gas Pipe Line Company, is a native of Massillon, Ohio, and graduated as a civil engineer from Michigan State College. He joined United Gas in 1934 as assistant engineer. In 1936 he was named engineer and in 1944 became supervising engineer, then assistant chief engineer. Prior to joining United, Pflug, from 1925-30, was design engineer and district manager of MaComber Steel Corporation, Canton, Ohio. From 1930-34 he was assistant district manager of the A. O. Smith Corporation.





Across the Rocky Hills Near Ranger, Texas

Blasted rock ditch on West Texas Gulf Pipe Line Company's 466 mile, 26-inch oil line from Colorado City, Texas, to Jefferson County on the Texas Gulf Coast. Associated used two 26-inch pipe line spreads to complete their 120-mile section of this project.

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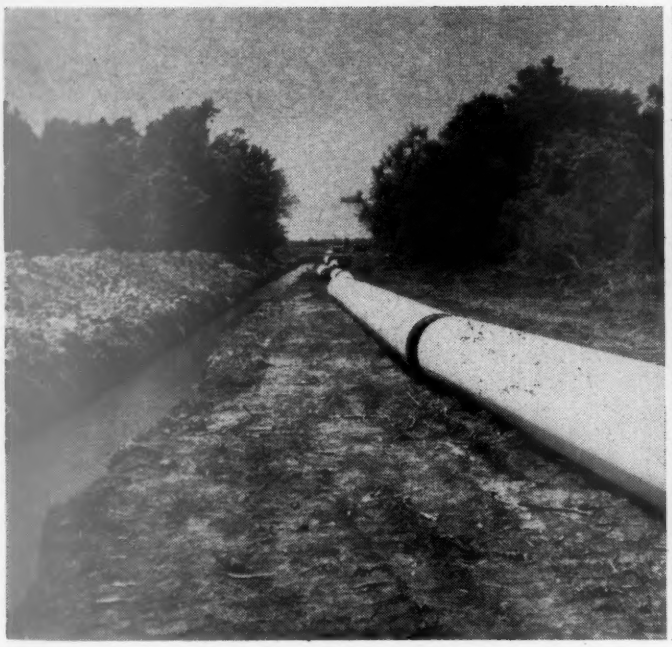


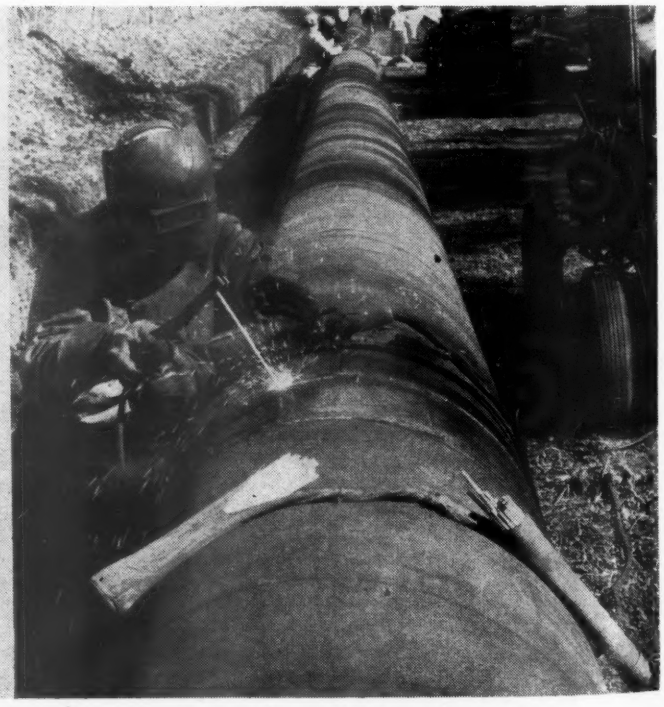
Thirty-inch pipe strung alongside of ditch at one of the few "high spots" where line could be laid by normal methods in South Louisiana coastal area construction. This scene is near Centerville, Louisiana.

Canal type ditch in which new pipe line was laid in deep South Louisiana area. Pipe was laid by shoving long welded sections of pipe with powerful machines from shove ramps specially constructed for the purpose.

ity. This area includes major portions of Texas, Louisiana, and Mississippi, and extends into south Alabama and north Florida. It is within this prosperous, growing region that United Gas serves some 461 towns and cities with natural gas either at wholesale or retail. The enlarged pipe line system, and allied facilities that will be required for its operation later this year, are being constructed for the multiple purposes of increasing the flexibility of the United Gas system, providing new and substantial additional reserves of natural gas, obtaining a more balanced distribution of reserves presently connected, and to provide capacity to meet requirements of a substantial additional volume of sales.

In actuality, the new pipe line construction is a vast grid that is laid over the company's other lines to create what is believed to be the most complex, but at the same time most flexible and efficient, pipe line system in the world. The grid will have a capacity of 1,450,000,000 cu ft of natural gas a day and will increase United's overall system capacity by about 50 per cent. It will give the system greater flexibility in obtaining natural gas at the most favorable sources along the Gulf Coast and transmitting it to other locations in the company's Gulf South territory. Upon completion of the present construction project the United system will have a

Pipe line construction spread along 68-mile section of 30-in. line in Mississippi.



Welding operations on Magnet-Witchers-Missouri City Junction line in United Gas Houston district. Nearly 8 ft of welding was required for each joint.

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- the cumulative purchases of 6,500,000 Payroll Savers add up to $130,000,000 per month.
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- monthly redemptions of unmatured E Bonds during each of 9 months (April to December, 1951) were less than 1% of the amounts outstanding.
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THE PETROLEUM ENGINEER

Two of the 20-in. Mississippi River crossing lines had been made, and the third was underway, when this picture was made in late October, 1951.

total daily capacity of approximately 4 billion cubic feet, which will mean that United will be the first natural gas company in the world with the capacity to deliver a trillion cubic feet of gas in a single year.

Major segments of the grid-system include a line that originates in the south Texas area to transmit gas to Monroe, Louisiana. This line is 30-in. in diameter for the most part. The other major part of the grid begins in the Gulf of Mexico, and with additional gas picked up from various points in South Louisiana, will transmit natural gas through a 30-in. line extending from the Louisiana shore to a terminus at Koscuisko, Mississippi.

The construction program in Texas includes 319 miles of 30-in. steel pipe, 53 miles of 24-in. and four miles of 20-in. In Louisiana, the grid includes approximately 430 miles of pipe lines varying from 8 to 30 in., and in Mississippi some 200 miles of 30-in., 24-in., and 20-in. pipe.

Other construction, as a part of the overall grid, will increase delivery capacity of natural gas to the Houston, Beaumont, Port Arthur, and Orange, Texas, areas. A new pipe line will connect several gas fields in southeast Louisiana with the system serving New Orleans and vicinity, and a new 16-in. line, originating at a tie-in with the older line between Mobile and Bay Minette, will supplement the gas supply to the Pensacola, Florida, area. There are

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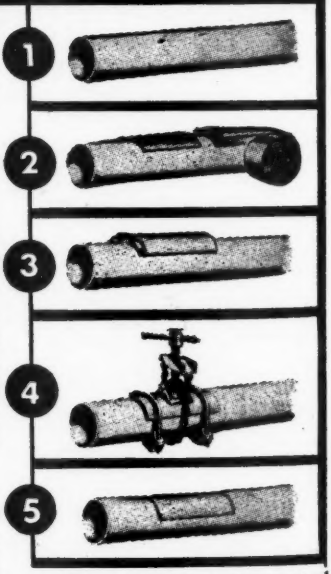

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A 30-in. valve and blow-off assembly before installation in the new line near Needville, Texas. An indication of the size of the fabrication is readily seen when compared with the company car.

also new gathering and transmission lines in north Louisiana to increase delivery capacity to the Monroe area, and other transmission, gathering, and distribution lines to serve thousands of additional customers from both the present and the new systems.

Most spectacular portion of the new construction was the sea-going lines constructed from the south Louisiana shore, a distance of approximately 25 miles into the Gulf of Mexico. This construction involved a 20-in. line extending 15 miles into the Gulf to a point near Pure Oil Company's Block 32 drilling platform. From Block 32 to the Magnolia Petroleum Company's Block 51 platform a 14-in. line was laid a distance of some 10½ miles. (See November, 1951, issue of *The Petroleum Engineer* for a detailed description of how these history-making sea-going lines were laid.)

A contract was awarded to Brown and Root, Inc., of Houston to cover various phases of engineering, construction, and other services on more than 1000 miles of the grid system. Gulf Southern Contractors of Fort Worth received a major contract for actual construction of approximately 1000 miles of the grid system. Gulf Southern is a contracting group composed of: Texas-Louisiana Contractors, Fort Worth; Oklahoma Contracting Company, Dallas; J. Ray McDermott and Company, Inc., New Orleans, and Morrison-Knudson Company, Inc., of Boise, Idaho. Because of the size of the overall construction job the above contractors pooled their resources and engineering skill for the purpose of undertaking this particular construction program. Robert Thomas of Fort Worth heads up the contracting group.

The enlarged integrated United Gas system is connected to more than 250 gas fields, compressor station capacity will be greatly increased, and 10 new dehydration plants will be constructed in the broad expansion program.

A total of 64,000 hp will be added to compressor station capacity for the new system through the addition of increased horsepower at four existing compressor stations in Texas, and the construction of six new stations. Additional horsepower will be added at the following stations: Refugio, 12,000 hp; Edna, 12,000 hp; Magasco, 2000 hp; Goodrich,

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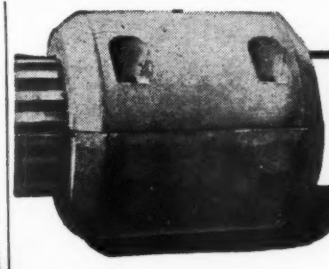

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write for the complete story of the Tennessee Crossing and additional information on River Weights and sizes available.

Photo shows how pipe line is "floated" across river.

Plants in: Decatur and Dothan, Alabama; Tampa and Ocala, Florida; Atlanta, Georgia; Kenvil, New Jersey; Binghamton, Port Washington, Rochester and Syracuse, New York; Columbus and Zanesville, Ohio; Norristown and Pittsburgh, Pennsylvania; Nashville, Tennessee; Clarksburg and New Martinsville, West Virginia.

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7920 hp. New compressor stations will be constructed at McComb, Mississippi, 8000 hp; Montpelier, Louisiana, 8000 hp; Lafayette, Louisiana, 4400 hp; Agua Dulce, 1760 hp, and Needville, Texas, 7920.

All compressor stations are so designed that additional capacity can be added when required, and plans also have been made for three additional stations in the future. The compressor buildings have full size basements for greater accessibility to the piping and better serviceability, and are designed for maximum natural light and ventilation. All station buildings, except the office, will be of the same general design as that of the main compressor building. Office structures will be of wood-frame construction covered with asbestos shingles.

Scrubbers, both the gas cleaner and the separator or liquid knockout type, or a combination of both types, will be installed on the inlet side of all stations. Both vertical and horizontal type of scrubbers will be used.

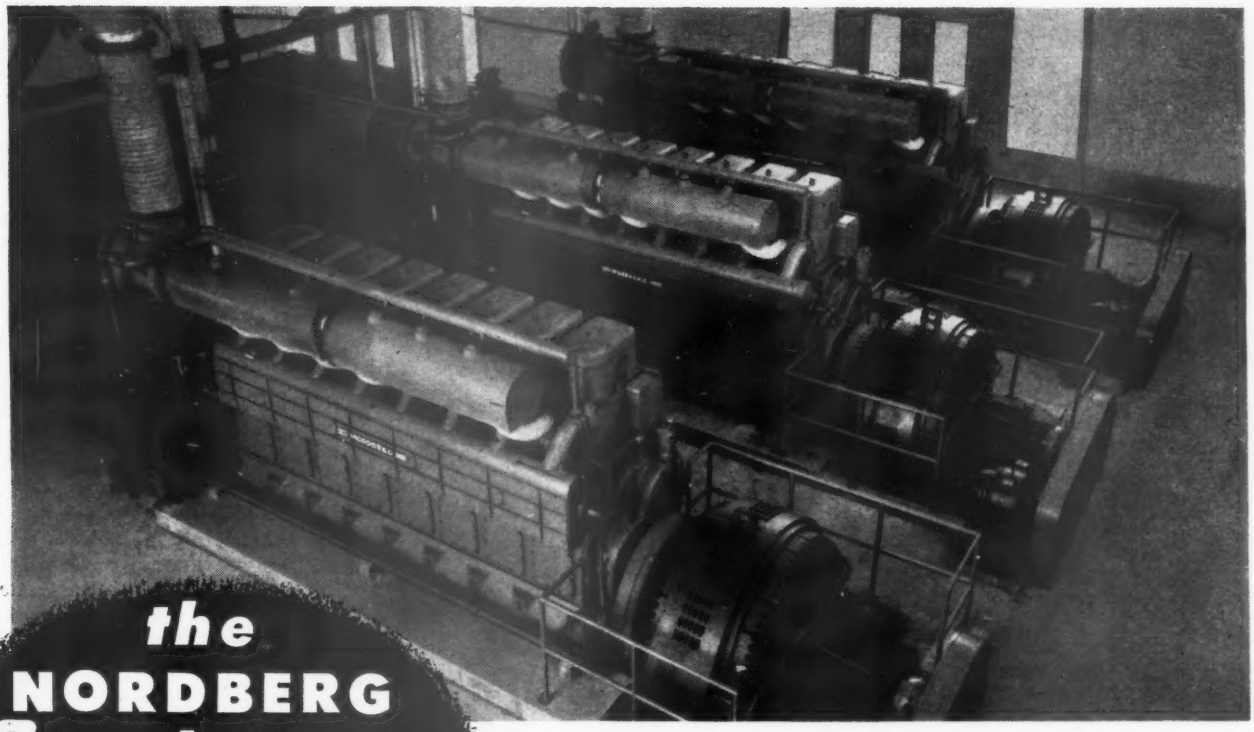
Near the origin of the line at the stations where field gas is being transmitted, greater emphasis will be given to scrubbers designed for the knock-out of liquid. For these installations, the cleaner-separator combination type of scrubber will be used, while at stations farther along the line cleaner-type scrubbers will be installed.

The compressor stations are being arranged for ease in making plant additions. General plan of station piping is to place the check meters on the inlet side of the station, followed by the scrubbers, with the outlet of the scrubbers leading to the station bypass and station suction. The gas passing through a station yard will be metered and cleaned before passing into the downstream line section.

Gas in the present United system in many cases will have to be pumped by the present stations into the lines being constructed. The piping in these stations is cross-connected and the compressor units also are arranged for connections to pump from various lines of different pressures. The entire compressor station operation is designed for a maximum of flexibility of gas transmission. Remote electric control operation of station valves and automatic station shutdown in case of pipe line break within the station yard has been incorporated in all stations.

Compressor units are of the angle type, equipped with automatic shutdown controls, and safety fuel shutoffs for the 2-cycle engine units. The units will be equipped with individual water pumps to handle the engine jacket water. The compressor cylinder jackets and the lube oil coolers will be cooled with water in a separate system.

Water is circulated in this latter system by means of motor driven pumps. Both the engine jacket water and lube oil cooling water are cooled in dry-type coolers of different makes and designs at the various stations. All these coolers



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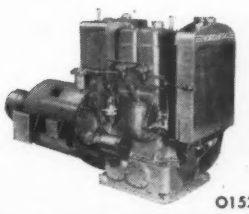

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will be equipped with multi-fans and have three-speed operation, which will serve to hold a constant temperature of the cooled water.

Fresh water will be obtained by pumping from deep wells, which were drilled at most of the station sites. In only a few instances was the water satisfactory for use without treatment, and at several stations considerable treatment will be necessary to hold the hardness below 3 ppm.

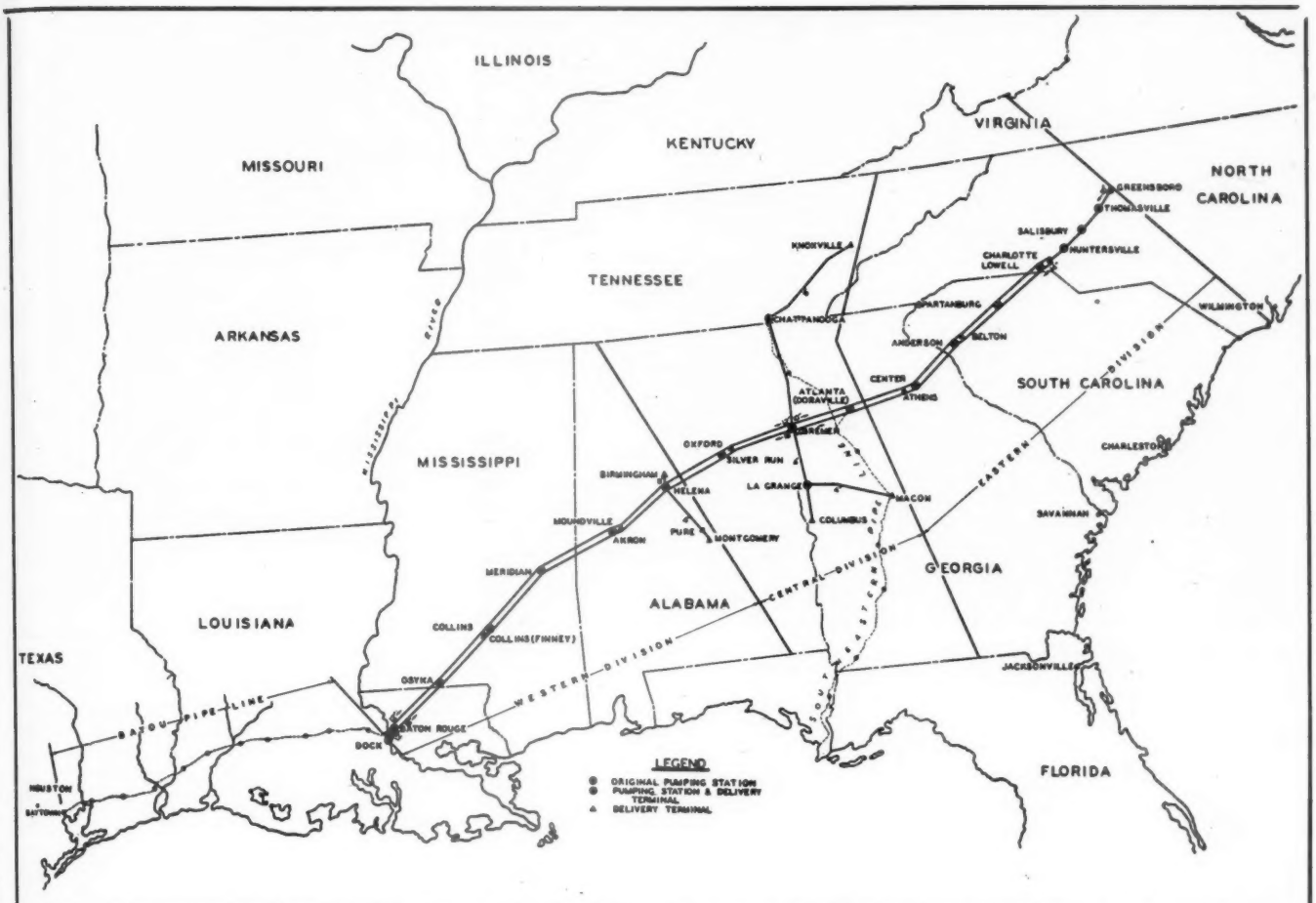
Lube oil systems at all the stations are designed to use both partial flow and full-flow filters on each main compressor unit. The lube oil system at each station also will include filter equipment for oil removed from the units during maintenance periods.

Ten new dehydration plants will be constructed as a part of the broad development program. These are situated as follows: In Mississippi at Baxterville; in Louisiana at Gibson, Lirette, Lafayette, Houma, and St. Martinsville, and in Texas at McFaddin, Refugio, Agua Dulce, and Edna.

Pipe line suspension crossings, which will span the Colorado and Upper Brazos rivers in Texas, the Red River in Louisiana and the Pearl River in Mississippi, are now in various stages of construction. Mississippi River crossings were made at a point near Modeste, Louisiana, with multiple 20-in. lines; and 8-in. line was laid in the river bed near Pointe-a-la-Hache, Louisiana.

Although the general typography of the Gulf South does not include mountainous areas, virtually every other type of terrain was encountered in laying the grid system of pipe line. Most unusual problems, of course, were encountered in the off-shore operations, but some 90 miles of pipe line laid through the marsh lands of the Mississippi River delta country of South Louisiana brought difficult engineering and construction problems. Along much of this construction string the water was not deep enough for boats, but it was too marshy and soft underfoot for successful use of conventional overland pipe line equipment. This problem was solved in the marshlands by laying much of the pipe in dredged canals. Dredges chewed canals, and were followed by barges from which pipe was strung and laid. An interesting sidelight on this portion of the construction program, which once proved the ingenuity of pipeliners in meeting special problems, was the use of pirogue cutters. Cutters were mounted on the front of the little shallow-draft marsh boats to cut through rank growths of grass and muck, and the ever faithful tools of dynamite and draglines also were called into play.

Final completion of United's present expansion program during 1952 by increasing the system capacity from a maximum of about 3 billion cubic feet of natural gas per day to a maximum of about 4 billion cubic feet, will give the United Gas system far more capacity than that of any other natural gas company. * * *



Map of the expanded Plantation Pipe Line system. Receipts at its source point at Baton Rouge, Louisiana, are by water movement, from a refinery at that point, and from the Bayou Pipe Line, which acts as a gathering system for Plantation. The Plantation system is approximately 1961 miles in length.

Complicated Dispatching Problem Solved

New dispatching board provides both visual and mathematical checks on each batch in transit

H. M. DREYER, JR.

DURING 1951 Plantation Pipe Line Company enlarged its main line system by paralleling its 12-in. line from Baton Rouge, Louisiana, to Bremen, Georgia, with an 18-in. line, and its 10-in. line from Bremen to Greensboro, North Carolina, with a 14-in. line as far as Charlotte. The facility from Charlotte to Greensboro remained unchanged, the new 14-in. and the existing 10-in. tying into the single 10-in. out of Charlotte. Stations are spaced on the new main line addition at approximate 120-mile intervals, and station spacing on the existing main line was reduced from 30-mile intervals to 60-mile intervals except in the section from Charlotte to Greensboro. Additional stations are now under construction to provide 60-mile station spacing on all main lines as far as Charlotte, while 30-mile spacing is maintained from Charlotte to Greensboro. Tank farms are provided at Baton Rouge, Bremen, and Helena, Alabama, and lateral lines extend from Helena to Montgomery, Alabama (4 in.), from Helena to Birmingham, Alabama (8 in.), from Bremen to Macon and Columbus, Georgia (4 in.), and from Bremen to Chattanooga and Knoxville, Tennessee (8 in.).

The first step of construction, providing 120-mile spacing on the new addition, permits an input capacity from Baton Rouge of approximately 175,000 bbl per day at 160 "C" factor, which is

EXCLUSIVE

The Author

H. M. Dreyer, Jr., a native of South Carolina, received his technical education at the University of South Carolina and the Georgia School of Technology. After several years' experience in civil engineering, he joined Plantation Pipe Line Company in 1942 as a yardman at a field station. Prior to his assignment as chief dispatcher in January of 1947, he held positions as stock clerk, dispatcher, and senior engineer.

FIG. 1. Dispatchers making postings on old dispatching board. Though adequate for its purpose and operated on the same principles as the new board, the many projections on the backboard and working surface made this a less efficient piece of equipment than the new replacement.

considered as a clean line, and the 60-mile station spacing will provide 221,000 bbl per day under the same conditions. Approximately 10,000 additional barrels per day enter the system at Doraville, Georgia, a point approximately 50 miles downstream from Bremen, as a transshipment from a connecting carrier. By the addition of stations to provide 30-mile spacing on both main lines, the input capacity of the system could be increased to an ultimate of 328,000 bbl per day.

The expansion of the system has introduced some very complex problems into the scheduling/dispatching functions. On the basis of shipper estimates, it was initially planned that the two main line systems would be completely segregated by grade of product as far as Charlotte. It was intended that all gasolines would move through the 18-in./14-in. system and all fuels (kerosines, tractor fuels, heating oils, and diesels) would move through the 12-in./10-in. system. Growth in the consumption of the heavier fuels has been so heavy in the area that Plantation serves, however, that it was found impossible to adhere to this plan. Dur-

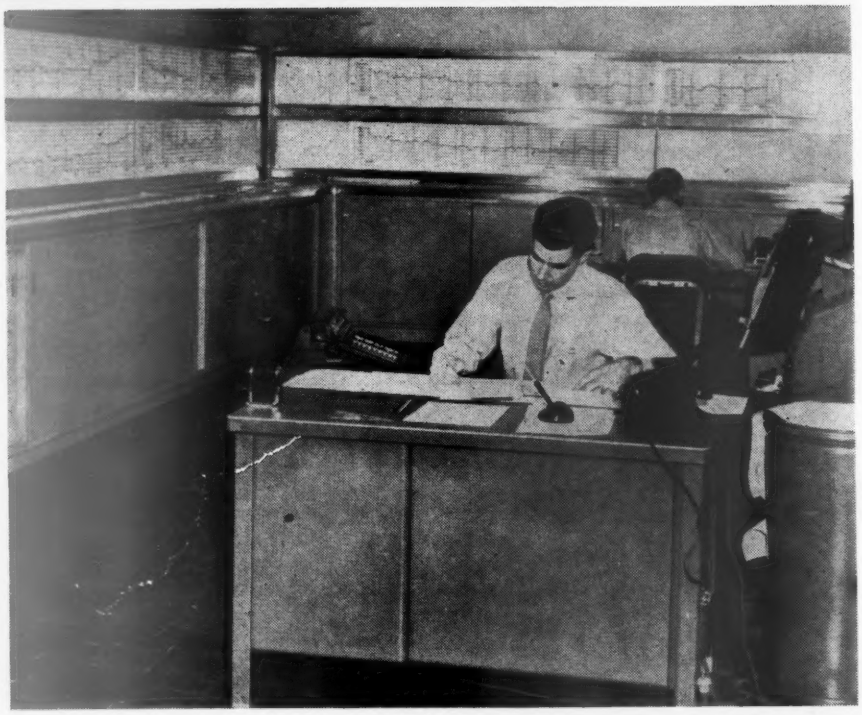


FIG. 2. *Above.* General layout of dispatchers' office with new board installed. The white plastic backboard surface and the grey enamel finish and stainless steel trim are identical with that used on control boards at the pumping stations. Note the ell shape which places each dispatcher close to the sections of the board representing the lines under his control. Teletypes and control consoles are grouped between the two dispatchers so that either may work at either line with a minimum of lost motion.

FIG. 3. *Below,* dispatchers and schedulers posting and calculating data at the time of a shift change during the daylight hours. Note the line profile on the backboard and the indicating lights at each station location. The lights are varied in color but appear as black dots in this picture. The teletype operator is sending delivery schedules to all field terminals for several days in advance.

FIG. 4. Dispatcher calculating arrival time of a batch change at a pumping station by measuring back on the proper scale from the station marker to the batch head. The color bandings on the lower edge of the tape indicate the owner of the batch and the type of product represented.

FIG. 5. Typical tape storage drawers at source point locations of main lines. Four such drawer sections are provided.

ing the winter months, one or more cycles of fuels must be introduced into the 18-in. line at Baton Rouge, and repetitive cycles of fuels must be introduced into the 14-in. line at Bremen.

A major complication in the successful scheduling of the main lines is the variance of capacity in the two lines that tie together at Charlotte and the single 10-in. from Charlotte to Greensboro. The 14-in. line at approximately 100-mile station spacing is capable of moving at 3000 bbl per hour while the Bremen to Charlotte 10-in. will move at only 1800 bbl per hour. Because of the 30-mile spacing of the stations, the 10-in. from Charlotte to Greensboro can move at an average rate of 2700 bbl per hour. This section of the line is scheduled to maximum capacity, but it is impossible to maintain top capacity in the section unless it is fed continuously from the 14-in., as the Bremen to Charlotte 10-in. does not have sufficient capacity to provide suction for it at its maximum rate.

In order to maintain continuous stripping deliveries, which will permit proper adjustment of the two lines at their joining point at Charlotte, it is necessary that those quantities of each batch that are destined for delivery at the two terminals downstream from Charlotte on the single 10-in. be removed from the main body of each batch and placed in tankage at Bremen. These quantities are then recycled and enter the 14-in. line in such a fashion that continuous flow to the Charlotte-Greensboro section is maintained. To facilitate this operation, all batches of products enter tankage at Bremen and are rescheduled from that point in such a fashion that the order in which they enter the system always provides for some batch to be in position for delivery at a terminal when a delivery at some other terminal is completed. Such an operation requires complicated and necessarily accurate calculations, which must be frequently revised and recalculated because of changes in shipper schedules.

An additional complication has been the inability of shippers to procure steel for additions to their terminal tankage

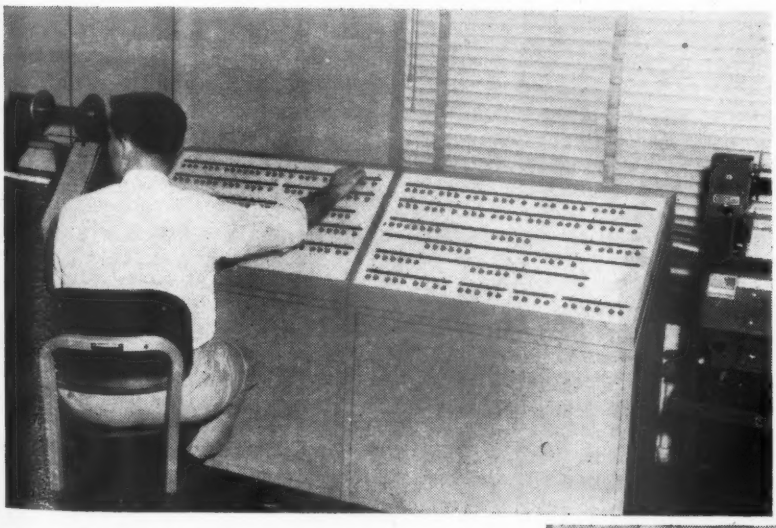


FIG. 6. Dispatcher operating toggle switch to turn similar indicating lights on or off on both the console and the dispatching board, reflecting an operation which has taken place at field stations in response to orders which he has issued. All communication is by means of teletype.

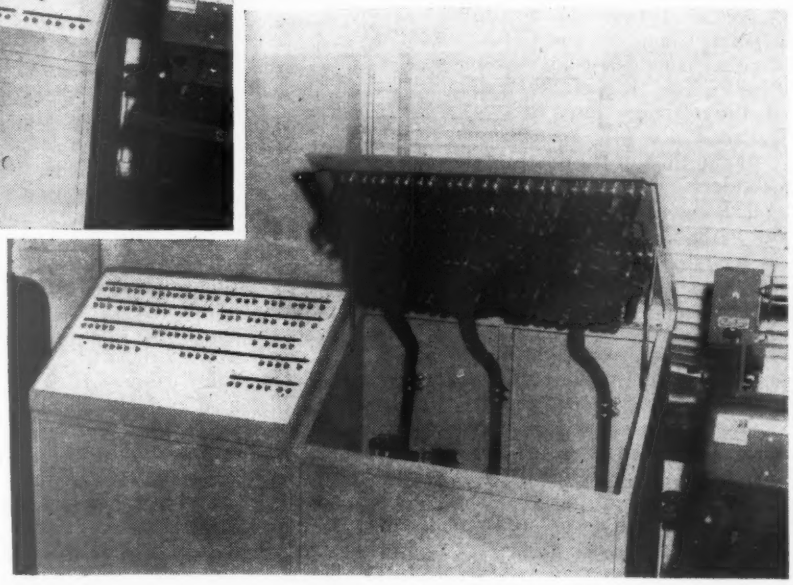


FIG. 7. View of one of the control consoles with the top raised to show wiring for indicating lights. Fuses and step-down transformers are located in this console. The face of the backboard is similarly hinged in sections to provide access to wiring and lights on the dispatching board.

in line with the increased throughput of the system. The lack of adequate shipper terminal storage causes frequent and extensive schedule changes. The maintenance of so delicately balanced a schedule and the efficient operation of so complicated a pipe line system requires the use of some instrument or equipment that will afford a means of obtaining both visual and mathematical checks on the progress of each batch in transit.

For the last 10 years, Plantation has used dispatching boards patterned on a patented device of this type developed by the Shell Oil Company. A very high degree of efficiency is obtained with minimum chances of error by use of this device. A series of scaled tapes banded with colors that indicate the owner of the product and the type of product represented are moved forward on the top surface of the dispatching board in accordance with the hourly report of metered input from the source point of each line in the system. The tapes pass before a number of markers representing pumping stations and delivery terminals, which are so constructed that they may be calibrated almost instantaneously to existing line conditions of temperature and pressure at the scale to which the tapes are printed. Maintenance of correct position and length of batches from which deliveries are made is obtained by means of cutting the tape representing the batch from which the delivery is taken and lapping it over each hour by the amount that is metered out at the delivery terminal during the preceding hour.

When considering the design for the new dispatching board, it was found that it would be necessary to reduce the scale of the tapes for the 18-in. and 14-in. lines in order to avoid an unnecessarily great length. A scale of 2000 bbl to the inch is used for the 12-in. and 10-in. lines, and a scale of 4000 bbl to the inch is used for the 18-in. and 14-in. lines. Doubling the scale for the 18-in. and 14-in. lines makes possible the use of the same tapes on all lines.

The old dispatching board provided a working surface of 18 ft in length, and the new board provides a working surface of 34 ft in length, satisfactorily accommodating the former 12-in./10-in. system and the four lateral lines as well as the new 18-in./14-in. system. Some spare working surface is provided for future additions or extensions to the system.

The board was so designed that working surfaces are, for all practical purposes, flush. Like the old board, the new board is equipped with a backboard, which indicates the profiles of the lines, the major block valves, and the various pumping stations. At each pumping station or delivery terminal, a series of colored lights indicates units being operated, sump pumps, or deliveries in progress. These lights are controlled from switchboard consoles placed adjacent to the dispatcher's teletypes so that an operation may be reflected on the dispatching board as soon as the report that it has taken place is received on the teletype. The backboard also is made as nearly flush-faced as possible. The profiles are applied on the under side of plastic sheets by a photo-emulsion process, and all indicating lights are of a coved type completely recessed behind flush surfaces. Drawers are provided for storage of rolls of tape at the source points of the main lines on the board. Considerable additional storage is provided by shelving in the balance of the board. The board was constructed in an ell shape in order that the dispatchers' working area could be utilized to maximum efficiency.

Although other systems of providing visual checks for scheduling and dispatching operations are completely workable, it is felt that the type used at Plantation is that most suitable to the complicated operation that Plantation must maintain in providing for the movement of 49 products owned by 14 shippers to 28 terminals on the two main line systems and the four lateral lines.

* * *

G. F. Mitchell Dies; Head Of AGA and Peoples Gas

George Franklin Mitchell, president of The Peoples Gas Light and Coke Company for the last 22 years, died March 26 in St. Francis hospital, Evanston, following a brief illness. Mitchell suffered a stroke at his home at 819 Milburn Street, Evanston, and was removed to the hospital shortly afterward.

Mitchell, who was 64 years old, had been a prominent figure in the Chicago utilities field for many years. He had been president of The Peoples Gas Light and Coke Company since February 26, 1930, and in addition was a director of Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company, and Chicago District Pipeline Company, all subsidiaries of Peoples Gas. Mitchell also was a director of the Chicago and Illinois Western Railroad.

At the time of his death Mitchell was president of the American Gas Association. Long active in executive affairs of the national association, he had served on many of its important committees, including the executive committee and the executive board, before he was elected association president in 1951.

Mitchell's career in the public utility field began in 1909 in Chicago when he went to work for Commonwealth Edison Company as a stenographer in the contract department. There he later became secretary to Samuel Insull, president, a position he held until March, 1919, when he was appointed assistant to the president of Peoples Gas.

George F. Mitchell

He was elected treasurer of Peoples Gas in June, 1921, at the age of 33 to become one of the youngest men ever to serve as an officer of the company. Mitchell was elected vice president in charge of finance in May, 1924, and became president six years later.

J. E. Polston, Pioneer Pipe Line Man, Dies

J. E. (Slim) Polston, manager of Service Pipe Line Company's Oklahoma Division, and one of the state's most widely-known men in the pipe line and oil industry, died April 3 after an extended illness. He was 63.

Polston, a resident of Shawnee, Oklahoma, since 1931 and active in civic affairs, became ill last August.

Born at Lenapah, Oklahoma, July 23, 1889, Polston had been in the oil industry since a boy.

He had seen Service Pipe Line Company grow from a small organization having some 400 miles of crude oil pipe line to one of the major transporters of crude oil with an eleven state system of more than 12,000 miles of pipe and 2600 employees.

As head of the company's Oklahoma division, Polston supervised 400 employees, the gathering operations from Oklahoma oil fields and the main lines crossing the state through which the oil is pumped to refining centers.

Polston joined the company that now is Service Pipe Line May 23, 1916. From 1916 to 1920 he was a connection foreman in the Kiefer, Bixby, Beggs, and other oil fields.

In 1920 he was promoted to district foreman with headquarters at Drumright, and in 1924 was advanced to Oklahoma division superintendent. He served in this capacity until 1945 when he was made division manager.

His life spanned the growth of the state's oil industry. Starting in the Kiefer oil boom, he went through development of the Drumright, Cushing, Oilton, and Shamrock fields and others —all names that spell out the color and romance of the oil industry to the old timers and others who delve into the history of the state.

In addition to the widow, Mrs. Clara Polston, of the home, 1809 North Park Street, survivors include, a daughter, Mrs. H. B. May, Shawnee; two brothers, J. Ray Polston, Tulsa, vice president—operations, Service Pipe Line Company, and W. F. Polston, Independence, Kansas, Sinclair Pipe Line Company district gager, and a sister, Mrs. Bill Ellis.

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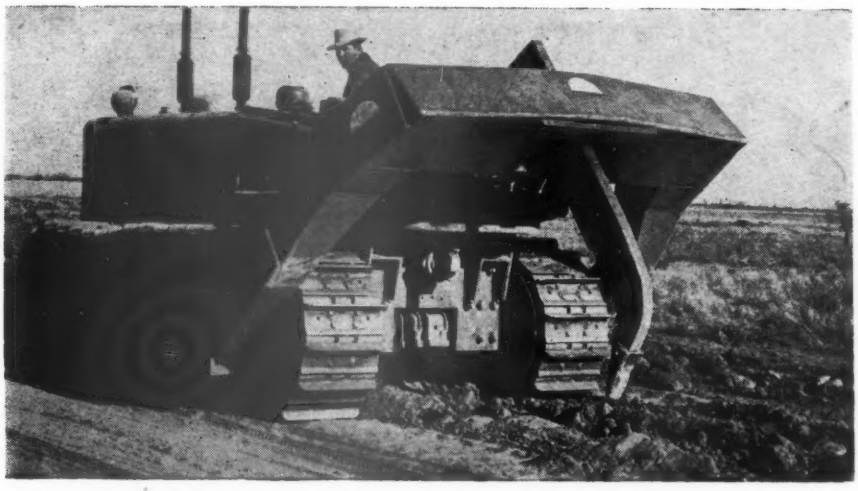

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Gagers Banks Bowling (holding sample can) and George Rambaugh are shown with the special equipment that takes a 5-ft core sample. Insert shows bottom of sampler showing trap and cord trip for closing.

Sampling Large Reservoirs of Stored Fuel Oil

Standard of California performs different kind of sampling job involving earthen reservoir and heavy fuel oil in which water remains suspended

EDWARD J. HYDE

SAMPLING of large reservoirs for determining net inventory or for locating nonmerchantable oil is a recurrent and dirty job, especially in the case of heavy oils. Various types of running thieves and trap thieves are used.

Standard Oil Company of California recently had occasion to tackle a somewhat different type of sampling job and the method and sampler used produced extremely good results. A 500,000-bbl earthen reservoir with a wooden roof was being used for the storage of cracked fuel oil at the Bakersfield refinery. The roof, which has an area of approximately five acres, was not watertight and over a period of time considerable rainwater had leaked through the roof and into the fuel. This fuel had a gravity of approximately 8-deg API, which at atmospheric temperature was heavier than water, with the result that the rainwater did not settle through the oil but remained suspended in it. It was important to sample the oil carefully in order to determine the exact location and amount of water present, and the maximum amount of specification fuel that could possibly be shipped direct to customers.

The reservoir contained approximately 150,000 bbl of fluid, with a gage of approximately 5 ft. A sampler was devised that consisted of an 8 ft length of 3-in. diam light duralumin tubing with a trap on the bottom and a cord trip for closing. A ¾-in. collar was welded on the tubing at 1 ft intervals, and through each collar a hole was drilled through the tubing and a ¾-in. plug was screwed into each collar. This sampler was lowered slowly into the oil through the roof opening and the trap on bottom was closed when the sampler reached bottom, thus procuring a 5-ft core sample. The sampler was then withdrawn and 1-ft samples were drawn from the sampler through the ¾-in. openings into separate containers. Sixteen separate cores were taken and their locations were marked on each container. Needless to say, this was not the cleanest and most pleasant job in the world. BS and W's were then obtained by centrifuge on each of the 1-ft samples and results were plotted on plan and elevation drawings of the reservoir.

It was found that the top 2 ft of oil had BS and W contents ranging from 4.2 to 13.7 per cent, whereas the bottom 3 ft was all near or under 1 per cent. By proper manipulation of swing pipes in the reservoir it was then possible to ship specification fuel to customers and to minimize the volume of oil necessary to be returned to the refinery for dehydration.

In this case the extra work of taking a large number of samples by the above described methods was well worth the effort. * * *

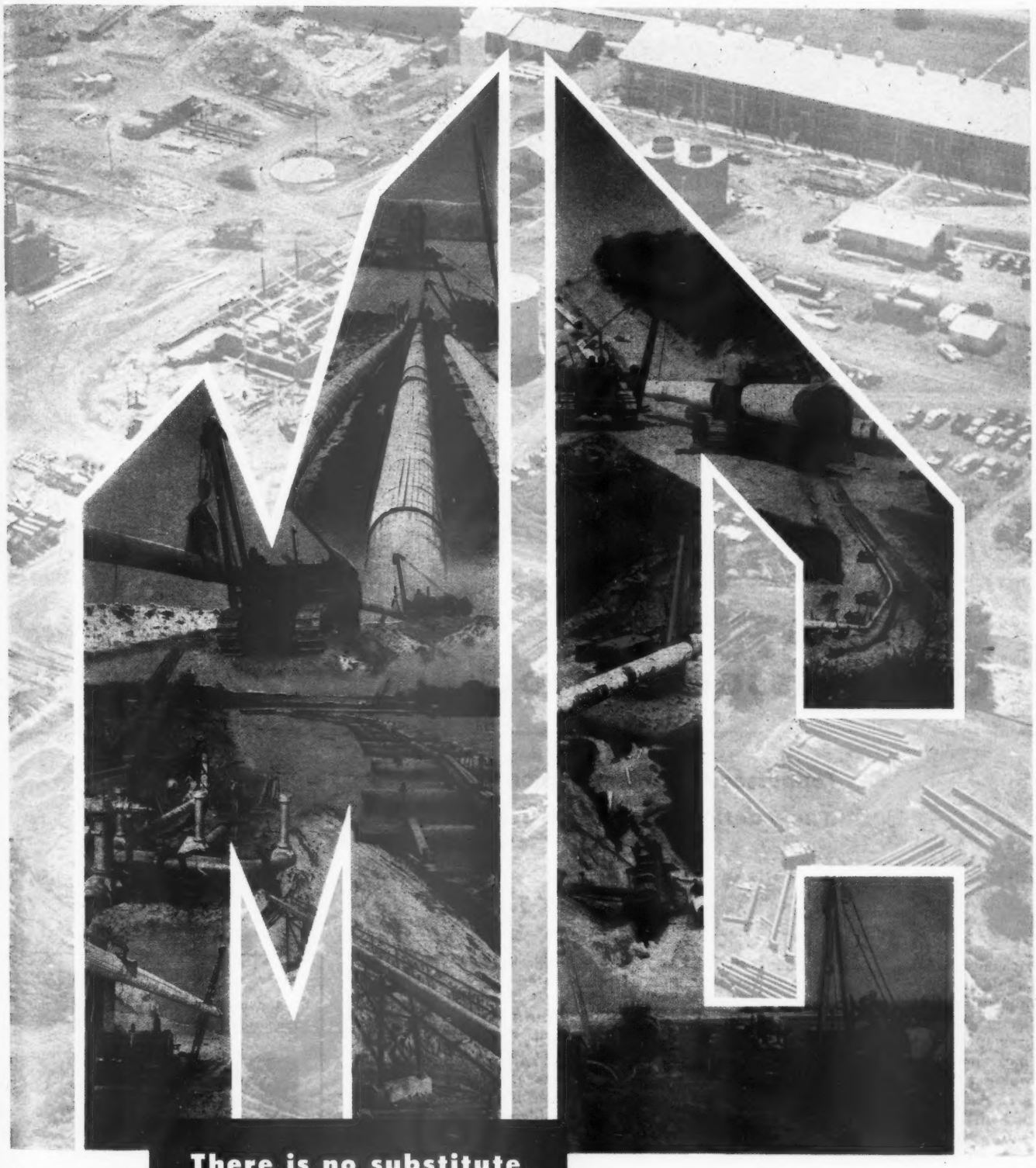
The Author

Edward J. Hyde is superintendent of operations control for the pipe line department of the Standard Oil Company of California. His headquarters are in the home office, San Francisco.

A 36-year-old native Californian, he is a graduate of Stanford University, where he took his AB in mechanical engineering in 1938.

Hyde joined the company immediately after graduation, as a roustabout in the pipe line department at Bakersfield. He rose to his present assignment after serving as a district engineer and foreman in southern California.

EXCLUSIVE



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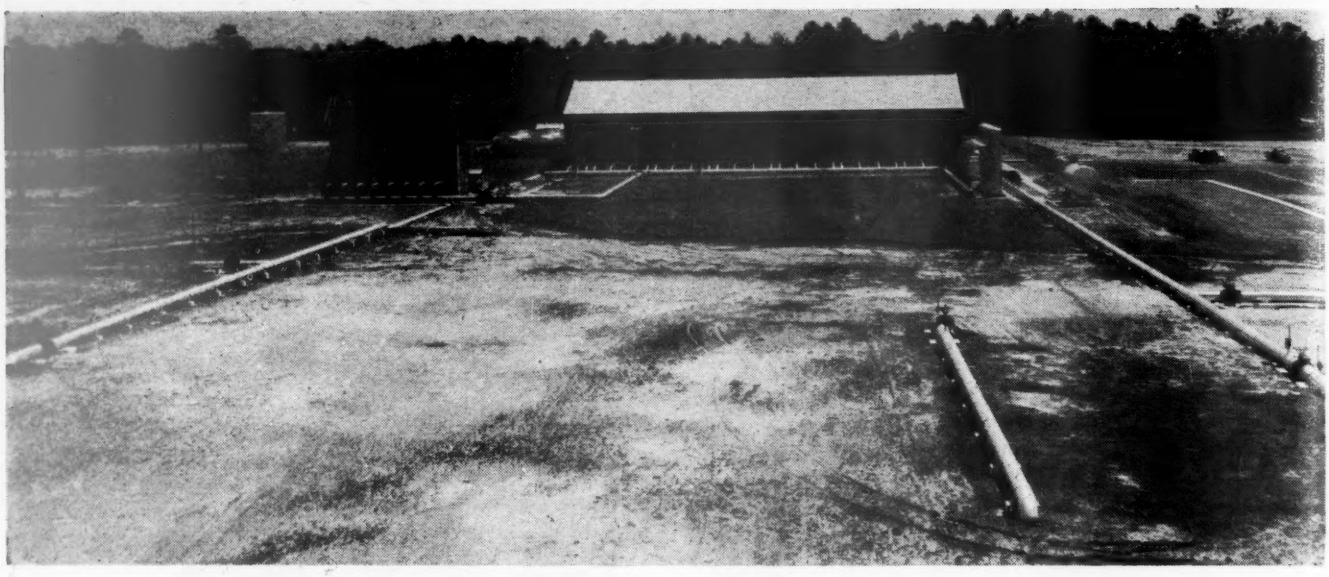

Typical piping connections for tying compressor building to the manifold system.

Compressor Station Piping Manifold

Tennessee Gas Transmission Company has developed a new design for multiple-line gas transmission systems

By B. T. MAST

IN general, the main design factors that should be considered and met in developing the tie-in piping system for connecting main line gas transmission compressor stations to main transmission lines should incorporate the following four requirements:

1. Sufficiently interconnected piping such that each compressor building or engine can pump suction from any of several transmission pipe lines passing through the plant yard.

2. Reliable and simple shut-down equipment to shut down and blow down the compressor plant in the event of an emergency.

3. Structurally sound pipe and fittings to withstand adequately line pressures, various mechanical loads occasioned by changing pressure and temperature conditions, and vibration or fatigue loadings.

4. Sufficient flexibility in the piping so that additional pipe lines and compressor facilities can be installed and tied in without the necessity of removing existing facilities from service in order to make the tie-ins, and further, to accomplish this without the use of hot-tap valves.

Past Piping Practices

General industry plant piping practices in the past have been based upon tie-in connections and valving consisting of a main line block valve and two side valves, one side valve for plant suction and one for plant discharge. Fig. 1-A illustrates a typical tie-in using this system. This arrangement will fulfill all general requirements outlined previously; however, when this system is extended by the addition of one or more main line loops and additional compressor buildings to pump additional gas, it very quickly runs into difficulties.

Fig. 1-B illustrates the steps necessary when this plan is followed to tie-in the first loop line to the existing compressor station. This piping arrangement is not particularly complex, but it should be noted that the tie-over lines to the first loop must cross the original line, and with large diameter lines, if

EXCLUSIVE

The Author

B. T. Mast, supervising engineer of the Tennessee Gas Transmission Company of Houston, Texas, graduated from Rice Institute in 1941 with a B.S. degree in mechanical engineering. He was an engineer for the United Gas Pipe Line Company 1½ years, plant utilities engineer for 6 months for U. S. Civil Service Commission at a shell loading plant at Minden, Louisiana, then entered the Army Air Force as an aviation cadet. He was a captain when released from active duty after his War II service, chiefly as maintenance engineer of aircraft. He has been connected with Tennessee Gas for six years, including two years as field engineer on construction, two years of general office engineering, primarily on special projects, and two years as supervising engineer.

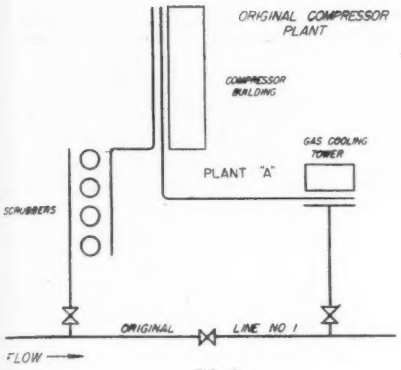

FIG. 1A

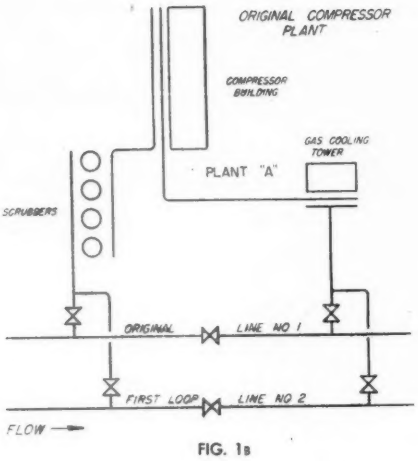

FIG. 1B

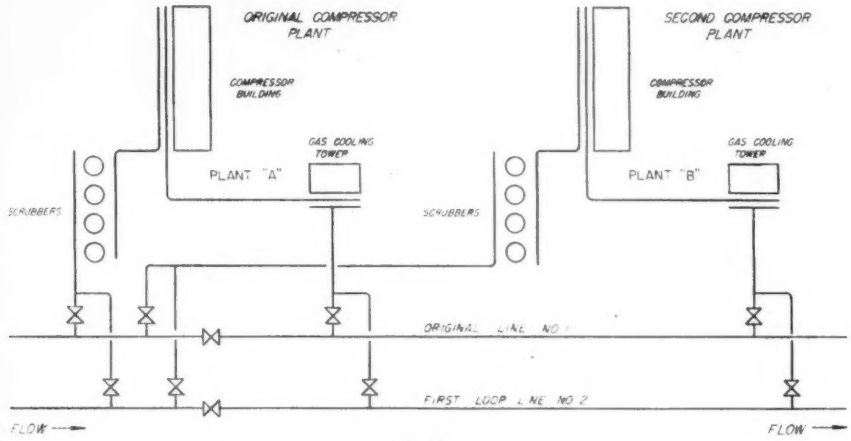

FIG. 1C

carried underground, would be rather deep and would require several bends to make the necessary changes in elevation to accomplish the tie-in. It should be noted further that only two additional side valves are required for the tie-in as well as a new main line valve.

Fig. 1-C illustrates, following the original pattern, the necessary steps to construct the second compressor building at this plant and to tie it in to both pipe lines. The location of this second compressor building, in most cases, would be on the same side of the pipe line as the original building. Because usually the first compressor building is built opposite the main line block valves, it will be necessary to run a suction or discharge line from the new building parallel to the main lines for a considerable distance in order to get on the proper side of the existing main line block valves for the suction or discharge tie-in required. As both lines one and two are in service, the tie-in valves either will have to be installed by the hot-tap process or the pipe lines will have to be removed from service and blown down in order that the tie-ins can be accomplished with regular valves. A considerable curtailment of service will be experienced while these lines are shut down. If hot-tap valves are used, they will, of necessity, be of smaller sizes, thereby introducing some added

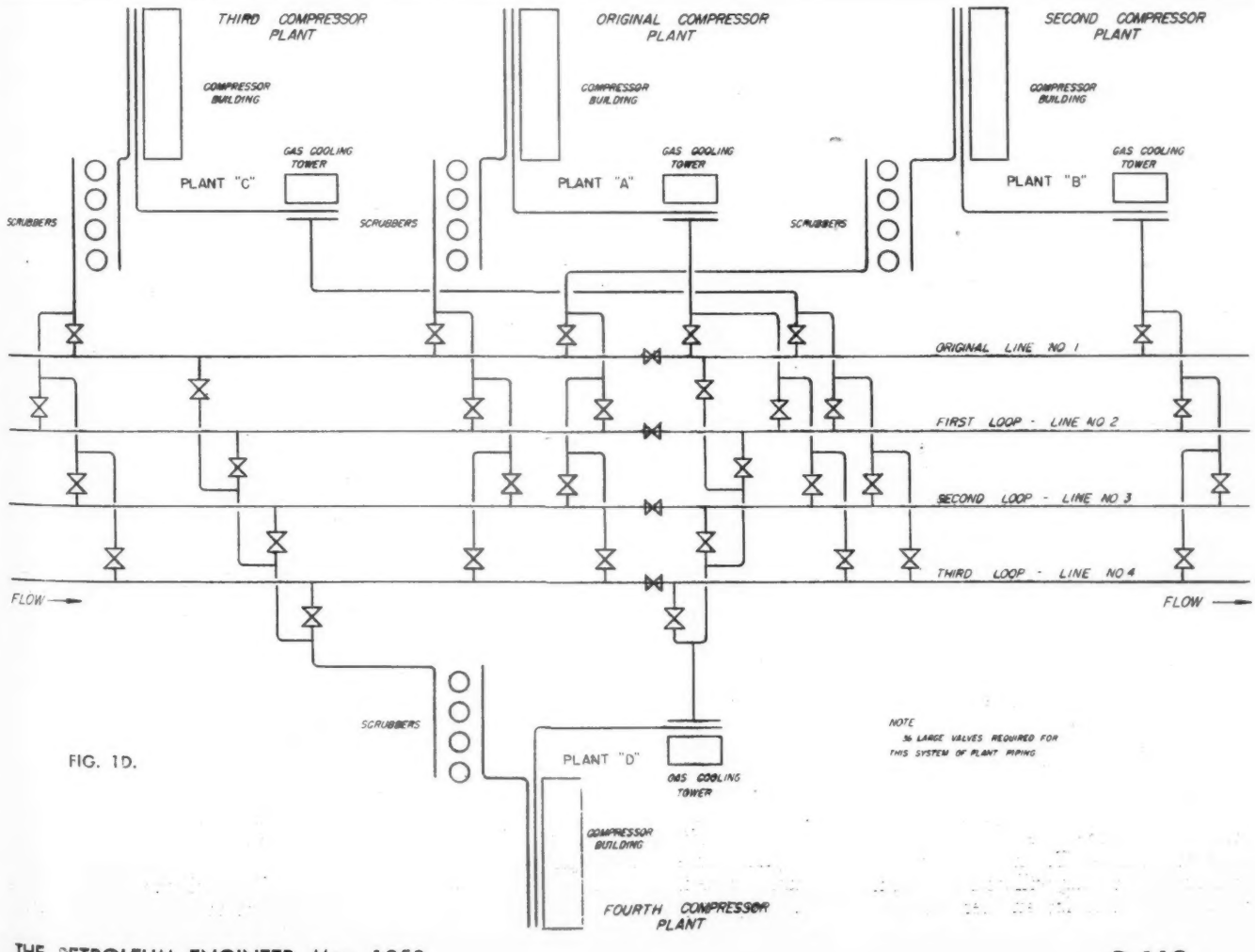

FIG. 1D.

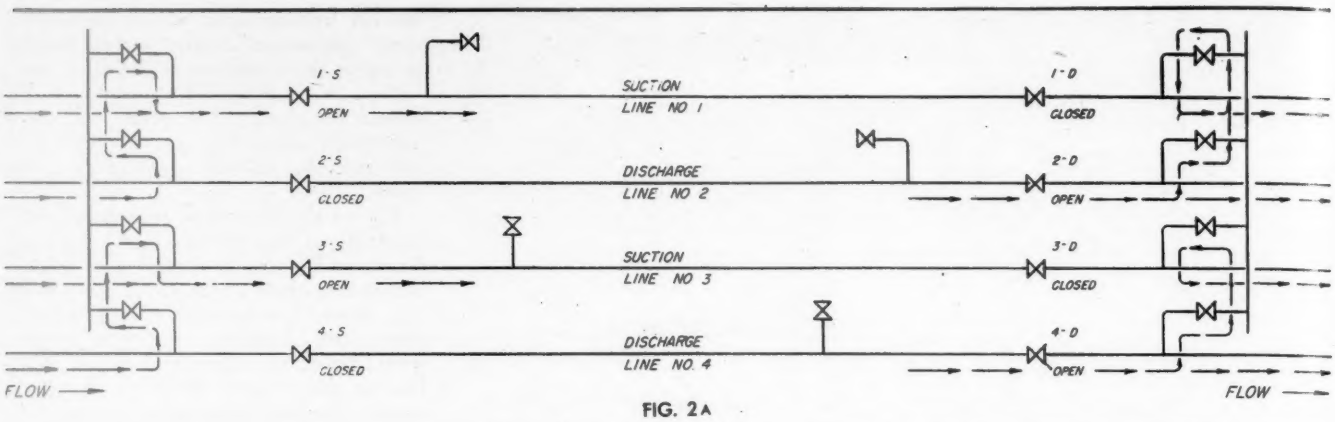

FIG. 2A

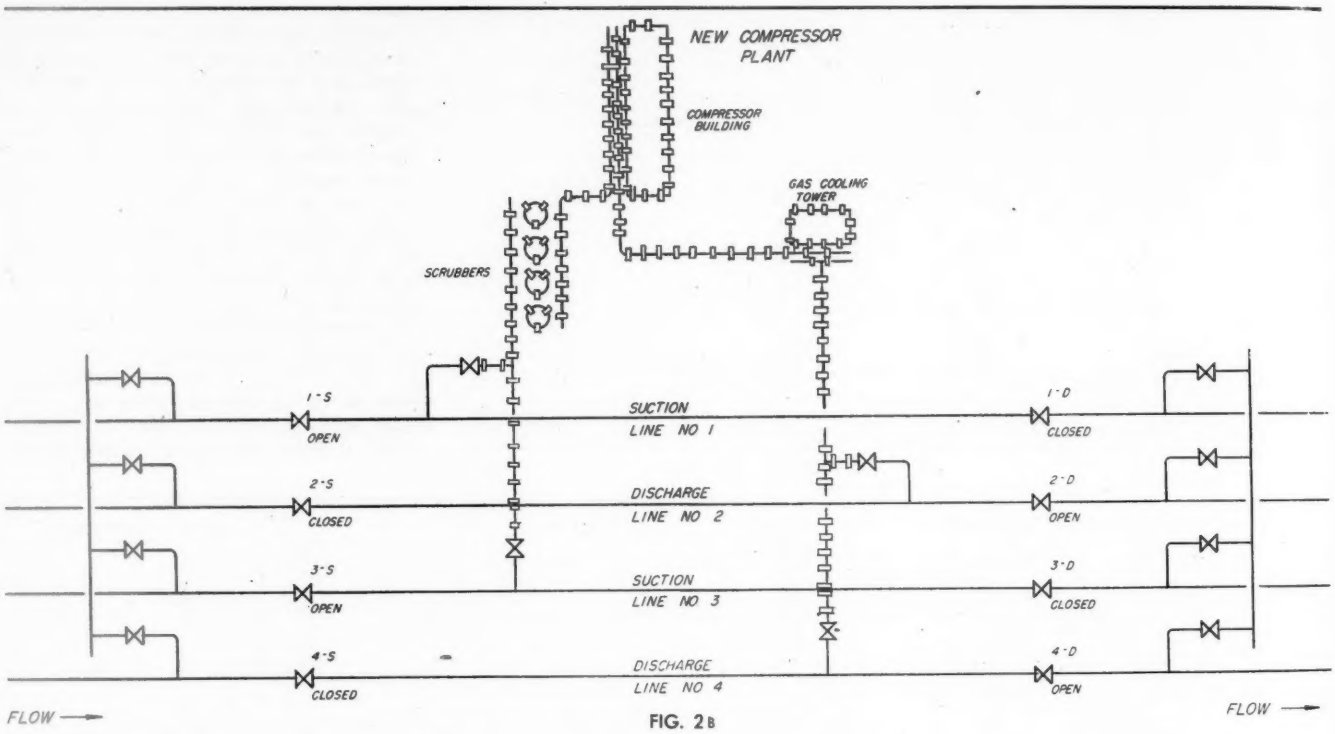

FIG. 2B

pressure drop within the plant yard piping. The difficulties encountered to this point are not particularly great, however, and this is still a feasible method of connection when only two pipe lines and compressor buildings are involved. Following this pattern through to a plant yard with four pipe lines laid across the station yard and four compressor buildings installed will lead to many difficulties.

As shown in Fig. 1-D, it will be seen that a very complex piping system has evolved with considerable design and operational difficulties, some of which are herewith enumerated:

1. A great number of hot-tap valves must be employed or a considerable number of shut-downs of facilities must be made.

2. A considerable number of cross-overs of large diameter, high-pressure gas lines will be encountered requiring the installation of a large number of pipe bends and excessive depths of some of the lines. Tie-in valves for one compressor building will be scattered in among the valves for another compressor building, causing considerable confusion on the part of the operating personnel as to which valves are necessary to control any one compressor building.

3. Many valves, by necessity, will be situated so close to plant facilities that they could not be reached to be operated in the event of a failure involving those facilities.

4. If each compressor building is tied-in to each of four pipe lines, it will require the operation of eight valves to isolate that building from the pipe line. In the case of four compressor buildings, 32 valves must be operated to isolate the plant, and, in addition, four main line block valves must be opened to by-pass the plant. This number of valves would be included in routine operation as well as during an emergency.

5. Depending upon the amount of heavy wall pipe installed in the original main line through the plant yard, in most cases, it will be found that if compressor buildings have been added to the plant there will be light wall cross-country pipe immediately adjacent to a considerable portion of the plant facilities because the future growth of the plant could not be envisioned at the time of original installation.

It can be seen that the pursuit of this method of piping becomes almost an impossibility in endeavoring to fulfill the basic design points considered above. It became apparent to Tennessee Gas that this method of piping could not be continued further as we proceeded with the design for the installation of the second loop and the third compressor building. As a solution to the problem, a piping system was developed that fulfills all the major requirements of a practical design, and will allow the tie-in of additional pipe lines and compressor buildings without a sacrifice of design strength and curtailment of service.

New Piping Manifold

The basic design of the new piping system consists of four complete pipe lines across the compressor yard using two main line block valves in each pipe line instead of the conventional single block valve. These block valves are situated at the extreme limits of the plant

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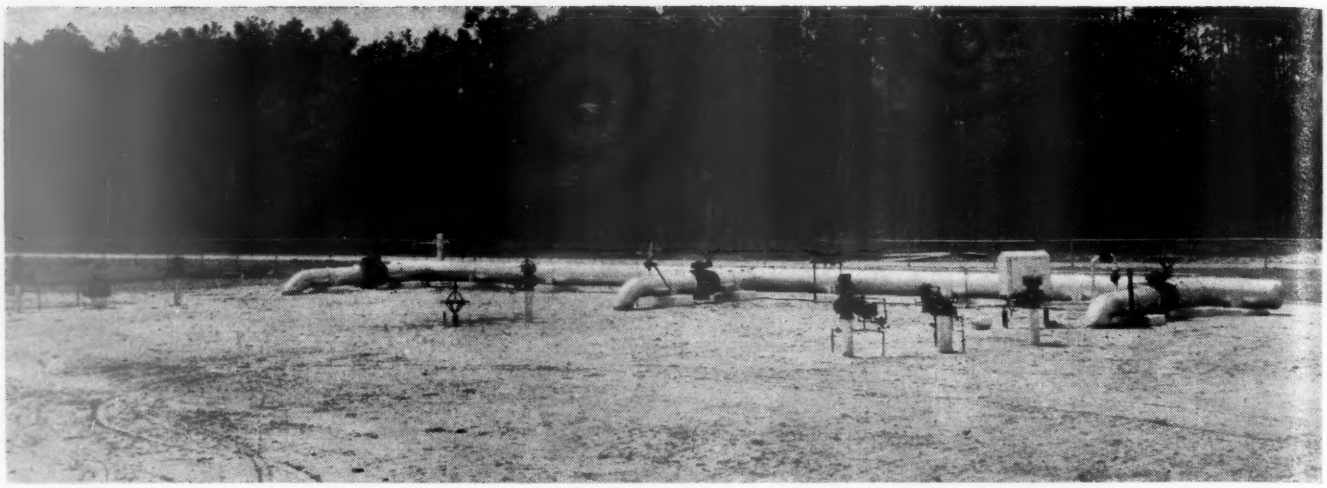


Suction manifold at one of Tennessee's compressor stations. This manifold is for a 3 pipe line tie-in. Foreground shows elevated gear housing valve equipped with operators, operator equipped blow-off and pipe line blow-off.

site and at a point beyond which it would never conceivably be desired to build additional compression facilities. At each end of the plant yard a cross-over manifold was constructed and tied-in to each pipe line on the pipe line side of the block valve.

Referring to schematic Fig. 2-A, it will be seen how this installation is made and the method of operation. The valves are operated as follows:

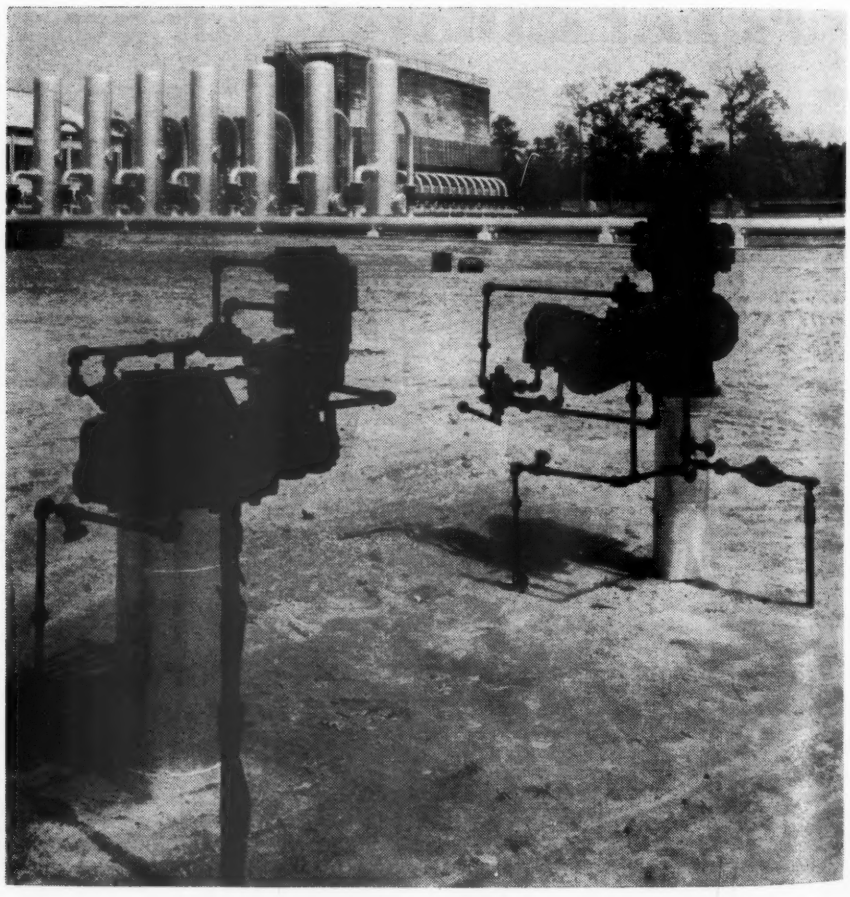
On Line No. 1, the block valve, marked 1-S, on the suction side of the plant, is left open, and the block valve, marked 1-D, on the discharge side of the plant is closed. The same applies to Line No. 3. The reverse procedure is applied to Lines 2 and 4, that is, the block valves on the suction side of the plant are closed, and the block valves on the discharge side of the plant are open. All valves of the cross-over manifolds are open. The incoming flow of gas of four lines is combined by means of the suction manifold into two streams flowing into the plant yard in Lines 1 and 3. Thus, suction pressure will exist across the plant yard as far as the block valves on the discharge side of the plant. In a like manner, the discharge gas from the plant flows out on Lines 2 and 4 only, through the open block valves, and is distributed by the discharge manifold to load the four pipe lines leaving the plant. Therefore, regardless of where a compressor building is constructed between the two block valves on each line, there are two suction lines to tie to and two discharge lines to tie to, eliminating the need for constructing any piping parallel to the main line.

Fig. 2-B illustrates the manner of tying in a compressor building to these four pipe lines. The tie-in is made in the following manner:

Close the block valve noted 1-S and blow down the section between 1-S and 1-D in the plant yard; cut this line, install a tee and side valve; close the side valve; reopen valve 1-S and place this line back in service.

During the time that the No. 1 line is shut-down, the side valves, providing suction to any other compressor building previously built, naturally is closed. The other plants obtain suction from the tie-in connection to Line No. 3, however, thus all pipe line facilities and all plant facilities continue operations during the time Line No. 1 is shut-down within the station yard. There will, of course, be a slight decrease in the system capacity due to extra pressure drop caused by the combining of the flow of all the gas through Line No. 3. This drop is not too severe, however, economically is a great saving compared with shutting down a 10 to 12-mile valve section of the main line to accomplish the same purpose without the dual block valve installation. Proceeding in a similar manner, shut down Line No. 3 between the block valves and set the other suction valve for the new plant. When this is completed, proceed in a like manner on the Lines 2 and 4, setting the new discharge tie-ins for the new compressor facilities. All main line

Operator-equipped main line valve and blow-off valve. Main line valve is a lubricated plug valve equipped with elevated gear housing. Blow-off valve is ASA 600 weld by flange lubricated plug valve.



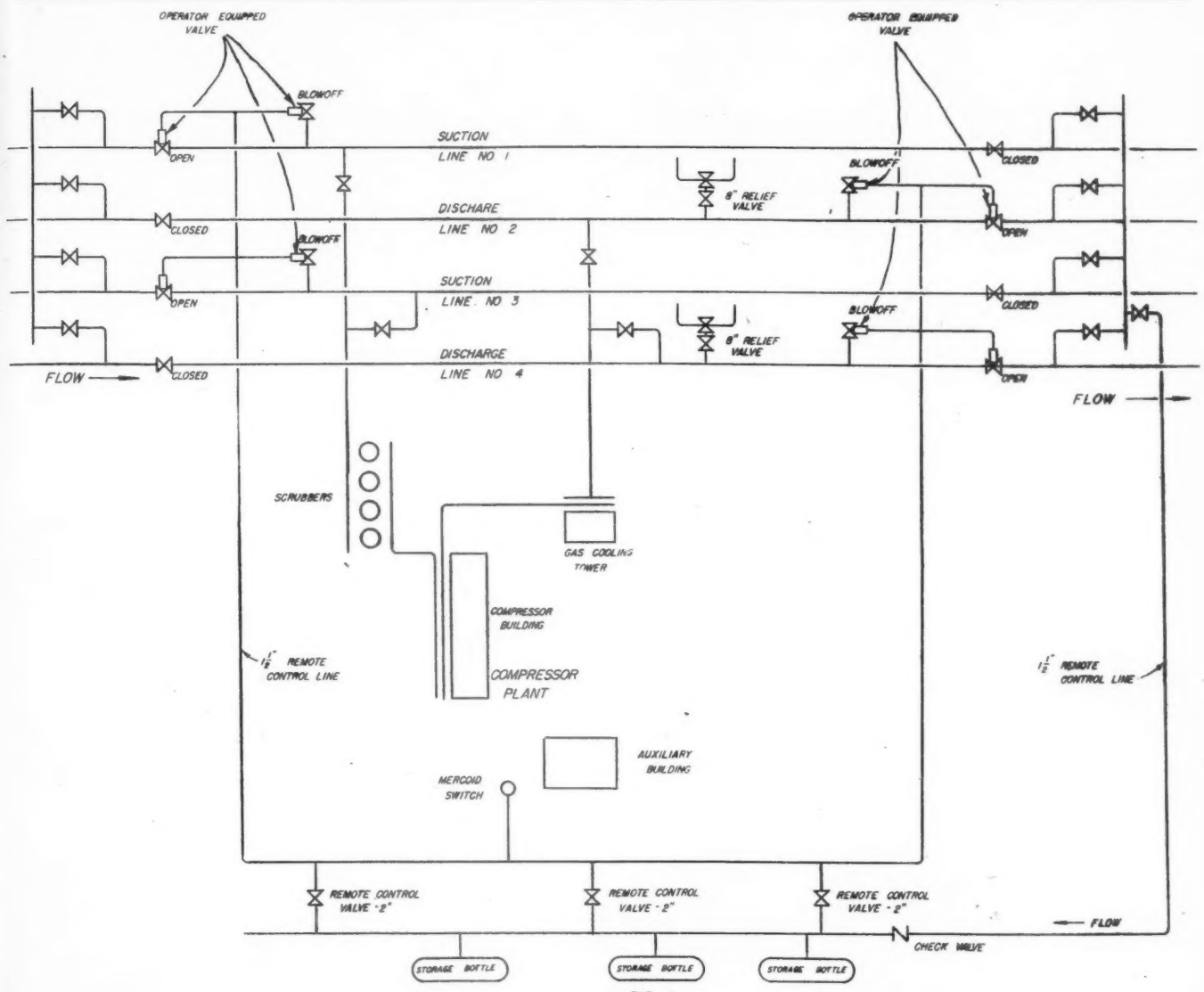


FIG. 3

work in the plant yard, either maintenance, repair, or the tie-in of new compressor facilities, can be accomplished by taking the affected line out of service. Performance of the work can be done in a safe manner and without any serious curtailment of pipe line system capacity.

The necessity for locating the scrubbers on the upstream side and the cooling tower on the downstream side of a single main line block valve has been removed. These facilities can now be situated anywhere between the two block valves irrespective of the direction of main line flow and still achieve a good tie-in connection without complicating the plant piping pattern. This design feature allows considerably more latitude in the location, arrangement, and interconnection of all the plant facilities when the direction of flow in the main line can be disregarded.

If it is desired to bypass the plant, it is only necessary to open the four closed main line block valves, making each pipe line a thoroughfare line through the plant. By closing the suction and discharge valves for the individual compressor buildings, the plant may be isolated from the main line and blown down if desired.

For future pipe line expansion it is not contemplated that there will ever be more than four lines laid across the plant yard. A fifth line loop would be tied in to the suction and discharge manifolds only, and not continued across the plant yard. It would be necessary to take the manifold out of service to extend it for the tie-in. While the manifold is out of service two pipe lines would be blocked off from the plant. These pipe lines, however, would only be out of service to the next main line valve installation where cross-overs are installed. Although a slight curtailment of operations would result from taking two valve sections out of service, it would not be necessary to blow these lines down and no appreciable amount of gas would be lost due to the tie-in.

Shut-Down System

This piping arrangement has made practical the installation of a simple, reliable remote control system for shutting down the plant in the event of an emergency. Referring back to Fig. 2-A, it will be noted that all gas enters the plant through two valves, the main line suction block valves marked 1-S and 3-S; and all gas leaving the plant plant passes through two valves, the main line discharge block valves marked 2-D and 4-D. It is only necessary to close these four valves and the compressor station will be completely isolated from the main line. Therefore, it is only necessary to provide, install, and maintain four power-operated valves to completely isolate the plant regardless of the number of pipe line loops or compressor buildings that are constructed at the station site. As only four valve operators are required, compared to a possible 32 in the previous piping system, it is much simpler and easier to maintain them always in an operable condition. The probability of failure of one operator out of four is much less than the failure of one operator out of possibly 32.

The suction and discharge block valves on which operators will be mounted have been placed at the extreme limits of the plant site, usually 1500 to 2000 ft apart and well removed

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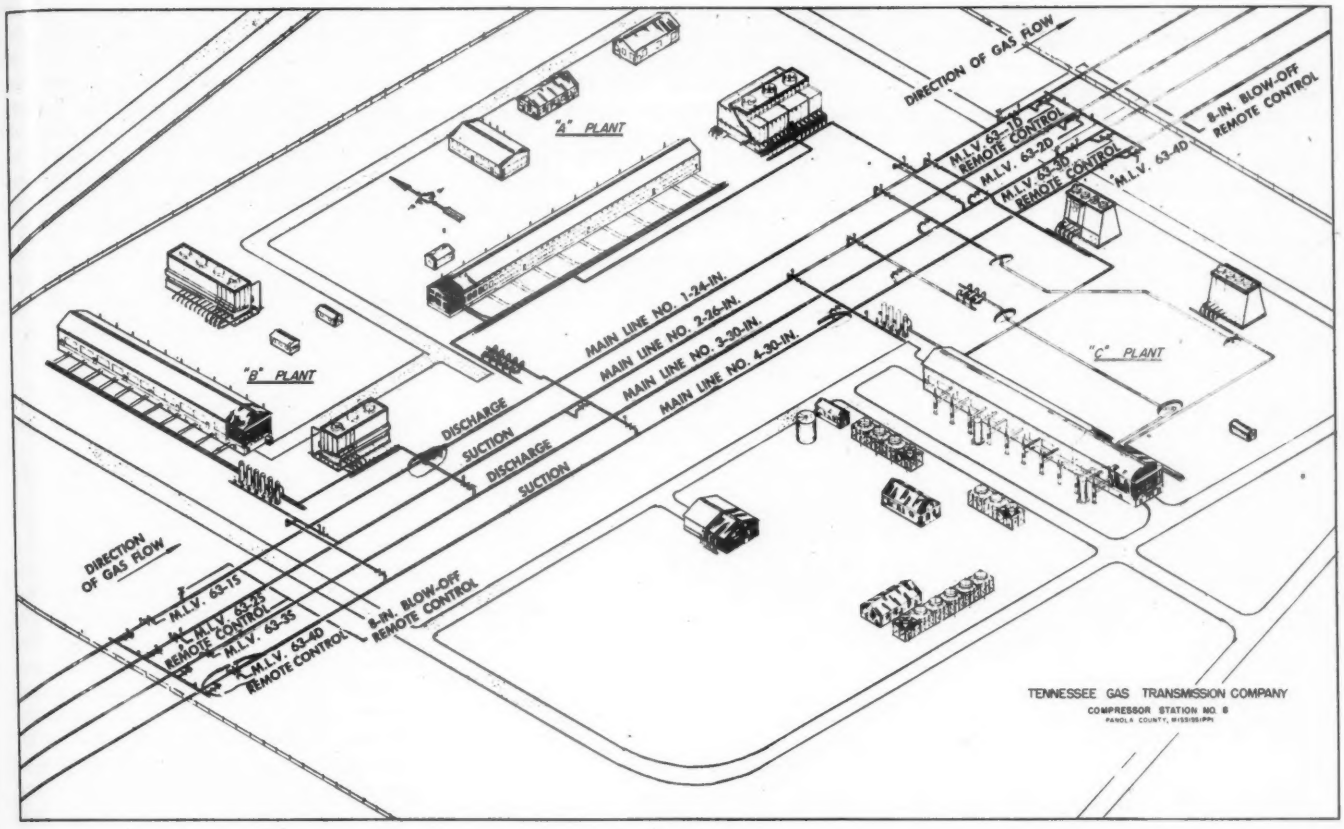


FIG. 4

from the plant area. In event of an emergency, and one of these operators should fail to close the main line block valve, then that valve would be sufficiently removed from the emergency area that it could still be reached and operated by hand without danger to the personnel operating the valve. In addition to blocking off all gas from the plant area, it was also desired to blow-down the plant as rapidly as possible during an emergency. To achieve this blow-down, an 8-in. blow-off valve has been installed on each of the four main lines through the plant and placed on the plant side of the operator-equipped main line valves. These blow-off valves are connected to the activating control piping in parallel with the main line block valves. Thus the process of blowing the plant down is started at the same time that the valves isolating the plant start to close.

Valve Operator Selection

At the time the remote control system was designed, three types of valve operators were available on the market. The first of these, an electric motor-driven operator, was rejected due to the possibility that the failure of the power supply could make the remote control system inoperable. The second type available was a cylinder and piston operator. The cylinder type of valve operator was rejected due to the difficulty of providing adequate maintenance such that they would be operable at all times. The operators also have a tendency to creep when installed on a closed gas system due to leakage of gas by the control valves. The third type operator was a low-pressure, i.e., 150-psi working pressure, gas turbine driven operator. This type was rejected because of possibility of failure of the necessary auxiliary equipment, which could make the remote control inoperable. The auxiliary equipment would either take the form of an air compressor and storage capacity or reducing regulators to reduce the main line gas pressure to the working pressure of the turbine.

At Tennessee's request, the operator manufacturers developed a new type of operator featuring a 1000-psi working pressure, high speed, vane type gas motor driving the handwheel shaft of the valve through a set of reduction gears. The gear drive does not include a maximum torque releasing clutch as previous operators of this type had included. As the primary purpose of the operator was to close the valve in an emergency, this clutch arrangement was omitted in order that a possible failure of its mechanism would not keep the valve from closing.

Even though there is the possiblity of breaking some of the shafts or gears of the valve or the operator, it is more desirable to employ the maximum available force to close the valve than to limit the force and take the chance on considerable damage to the plant. Any gear breakage during emergency would be insignificant compared to the possible damage to the plant if a main line valve were not immediately closed.

Previous operators employed a considerable number of rather delicate parts in the form of counting gears, mechanical linkage, poppet valves, etc., to activate limit valves to close off the gas supply to the turbine when the main line valve had reached its closed position. This type of limit valve system was abandoned in favor of a globe or slide type valve, spring loaded in an open position and closed by a cam that was mounted either on the main plug shaft or driven through a set of heavy reduction gears driven from the valve handwheel shaft. As the limit valves are spring loaded in an open position, they could not be manually closed and left closed through oversight or neglect. Failure of this limit valve to close would occur only after the main line valve had been closed and the mechanical stops built into the main line valve will stop the motor.

In order to reopen these valves with gas power, the operator has been provided with a gas supply from a separate source than the remote control system. This supply is introduced to the gas motor through a 5-way manually operating reversing valve. This 5-way valve is spring loaded with a heavy spring to keep it in the desired position for the emergency service. The operator can be reversed only by a man holding the 5-way valve in a reversing position, and as soon as the handle is released the 5-way valve will return to its proper position. These high-speed motors are timed to close the main line block valves in from 10 to 15 sec and to open the blow-off valves in approximtely 5 sec. The blow-off valves are so sized that the plant can be shut-down and blown down in approximately 2 minutes.

Remote Control System

Fig. 3 illustrates the most pertinent features of the remote control system. Gas supply is obtained by a tap on the discharge manifold. Discharge pressure is used in order to have available the highest pressure around the plant, thus conserving the size and quantity of storage bottles necessary to provide an adequate reserve of gas. Gas from this tap is conducted into storage bottles through a check valve. This check valve is to insure that a pipe line failure on the discharge side of the plant would not bleed off the gas reserve available to operate the remote control system. A line from the storage bottles then goes to a valve on the line, which is the system's activating valve called the remote control valve. The system to this point is always pressurized from the check valve to the inlet side of the remote control valve. The gas is piped to the four main line valve operators and the four blow-off operators, all being connected in parallel. The remote control valve is a manually operated 2-in. plug valve. Opening this 2-in. plug valve admits the gas to all operators simultaneously. There are no other valves between the remote control valve and the operators that could be left closed through oversight, neglect, etc., which would prevent the operator from working. There are several of these remote control valves at different points around the plant yard in sheltered places convenient to personnel always on duty.

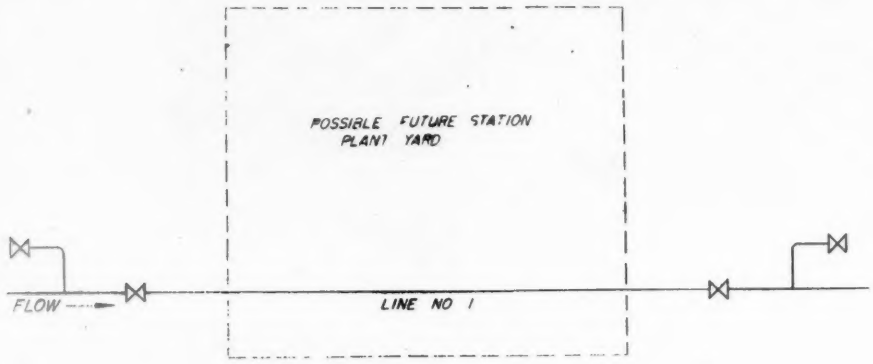


FIG. 5A

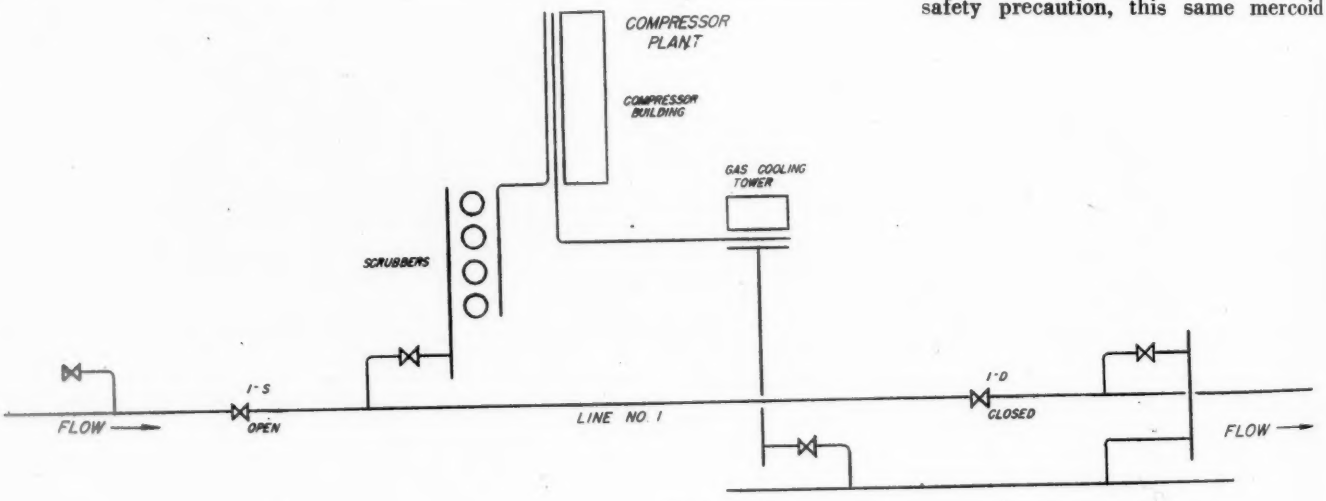


FIG. 5B

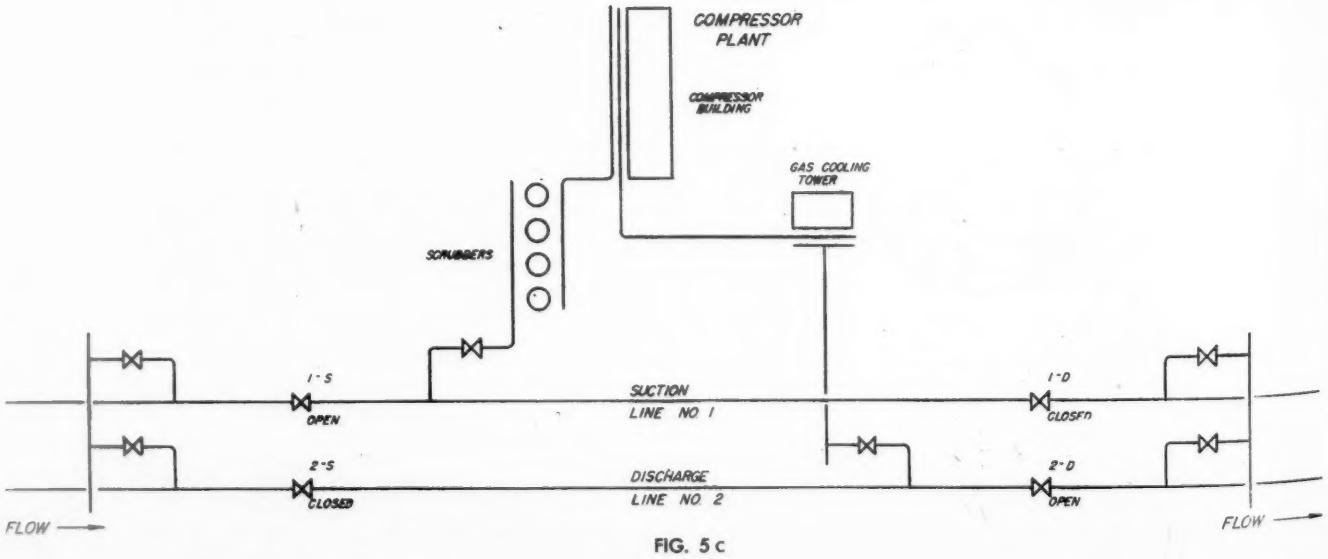
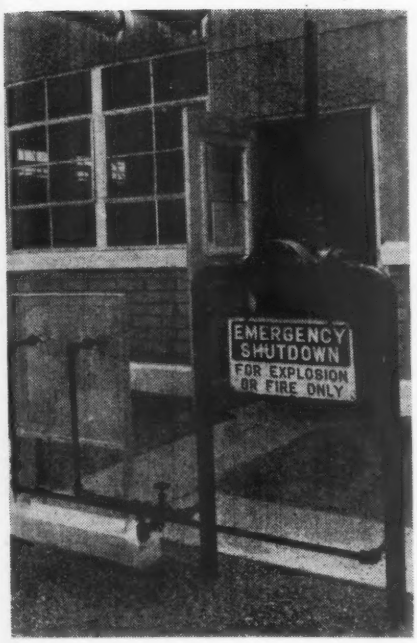


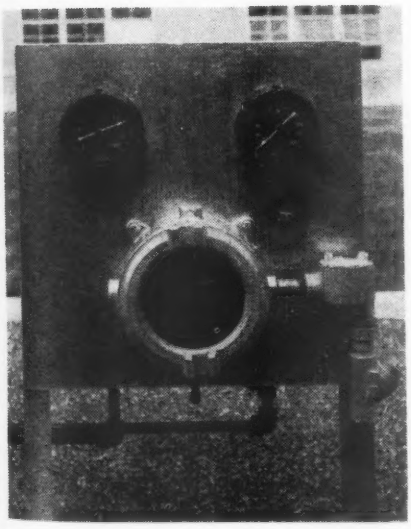
FIG. 5C

Additional Safety Features

In event the discharge main line block valves close before the suction valve, and the blow-off valves fail to open, it would be possible for an excessive pressure to build up on the discharge side of the engines. To prevent this from occurring, a gas operated mercoid switch is provided on the remote control piping between the remote control valve and the valve operators. The same gas pressure that activates the valve operators will trip the mercoid switch, which closes electrical circuits and energizes trip coils installed in the circuit breakers in the compressor engine ignition system, shutting down all compressor engines. As an additional safety precaution, this same mercoid



Remote control valve installation at auxiliary building. Panel stand contains pressure gages showing pressures of pressurized and nonpressurized portions of control pipe system and Mercoid switch for shutting-down compressor engines.



Front view of panel showing pressure gages for pressurized and nonpressurized side of remote control valve and Mercoid switch.

switch trips the circuit breakers that supply all power and lights to the compressor buildings, in order that these circuits will not start a fire in the event of a pipe line break at the compressor building. The electrical systems incorporate dead-man type bypass switches around the circuit breakers so that the action of the electrical system can be periodically checked to see that it is in operable condition.

A second safety precaution was installed in the form of two 8-in. double outlet relief valves mounted upstream on the discharge main line block valves.

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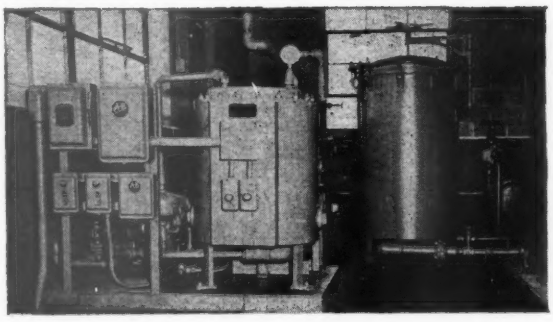

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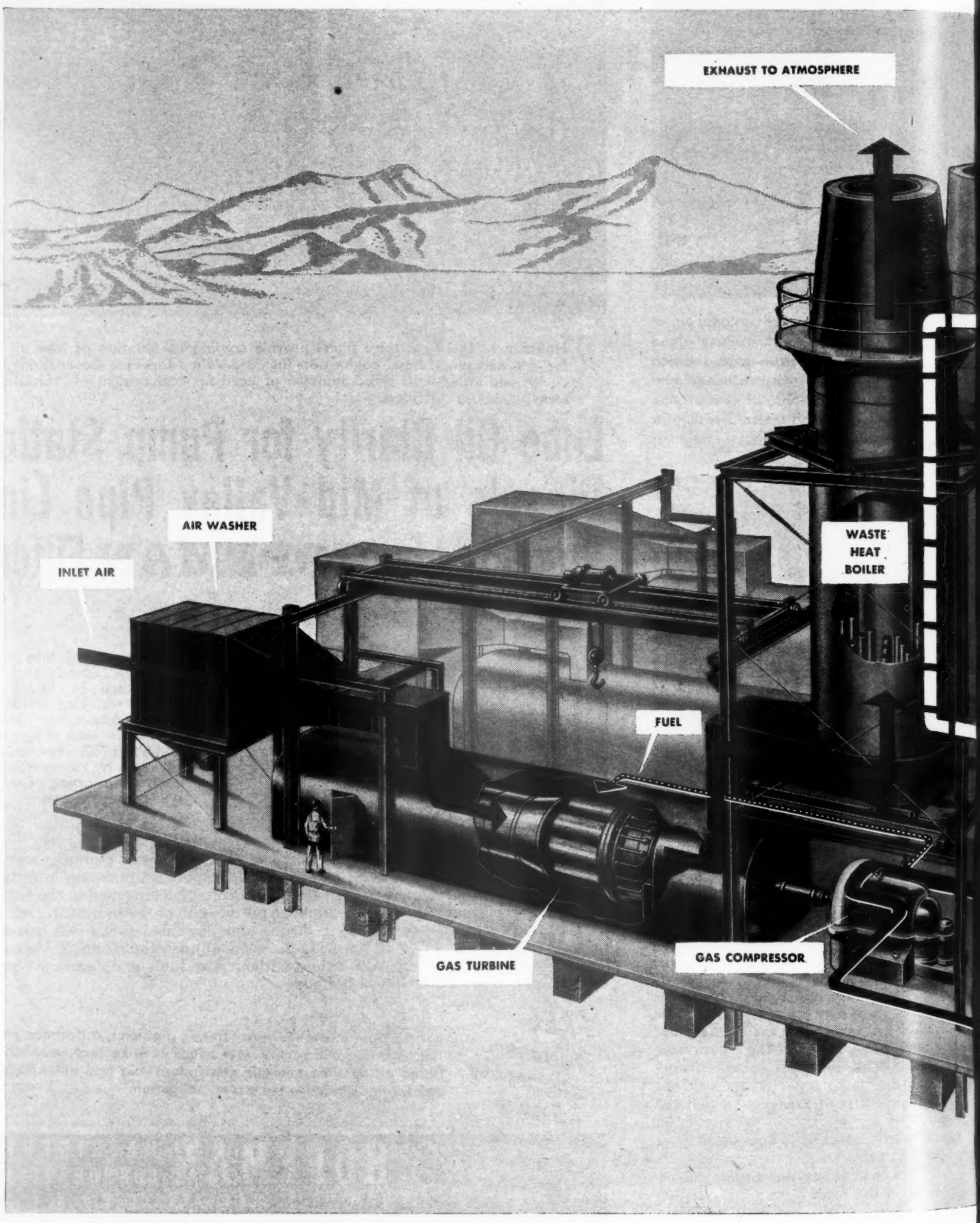

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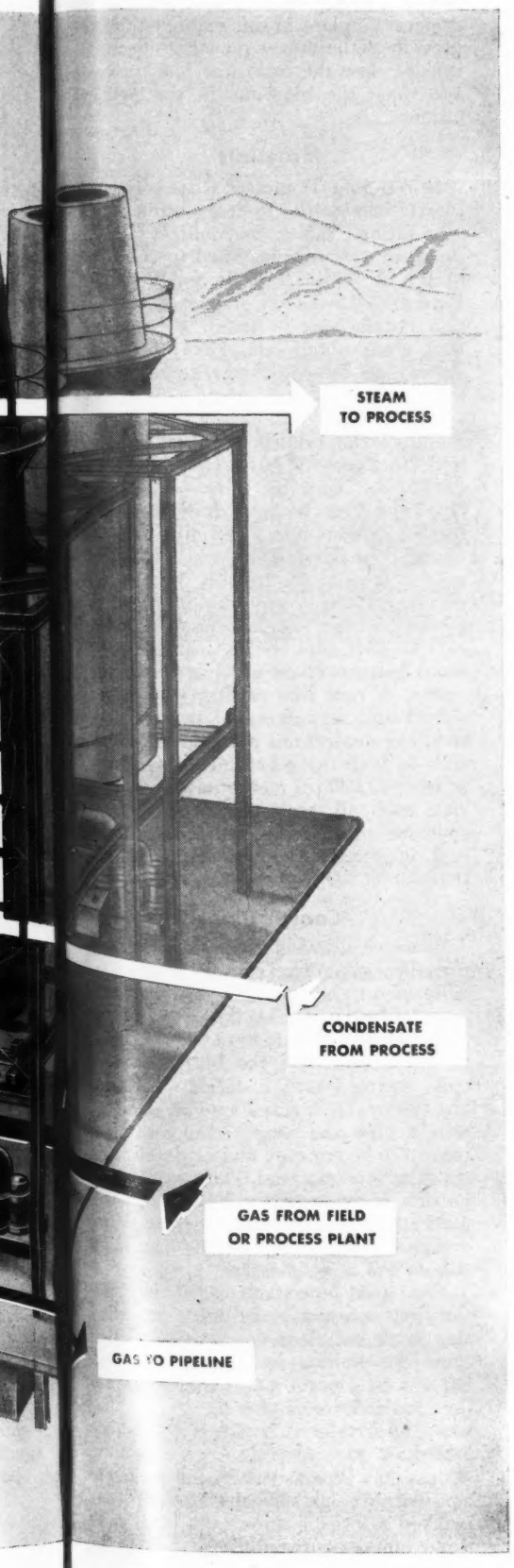

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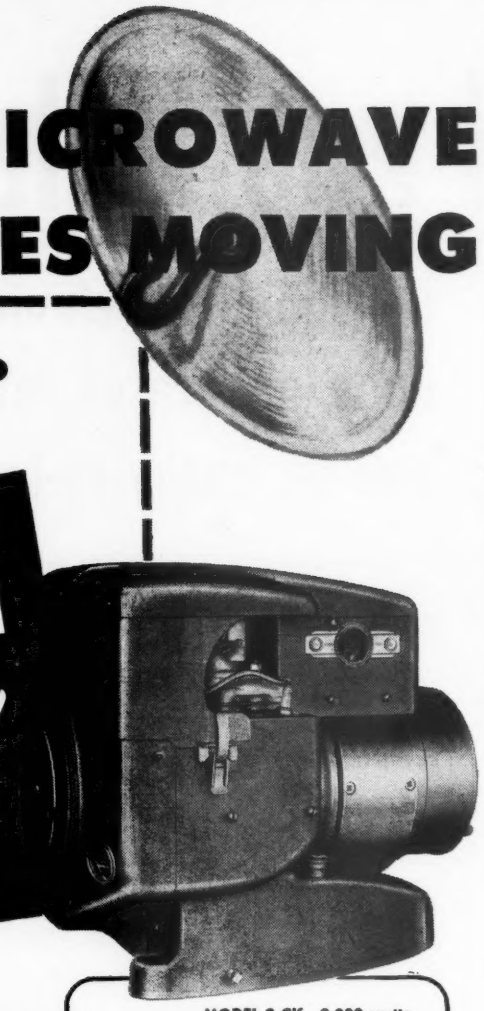

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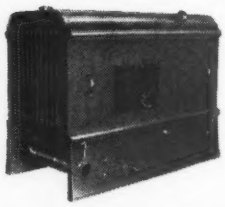

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These valves are set at a pressure point approximately 10 psi higher than the normal operating pressure of the pipe line. Additional relief valves are provided on each individual compressor engine's discharge.

Therefore, four distinct means have been built in to protect the discharge side of the plant when the remote control shut-down system has been activated. It is considered more feasible to protect the plant in this manner than to provide elaborate sequencing mechanisms to close the main line block valves and open the blow-offs in the proper order.

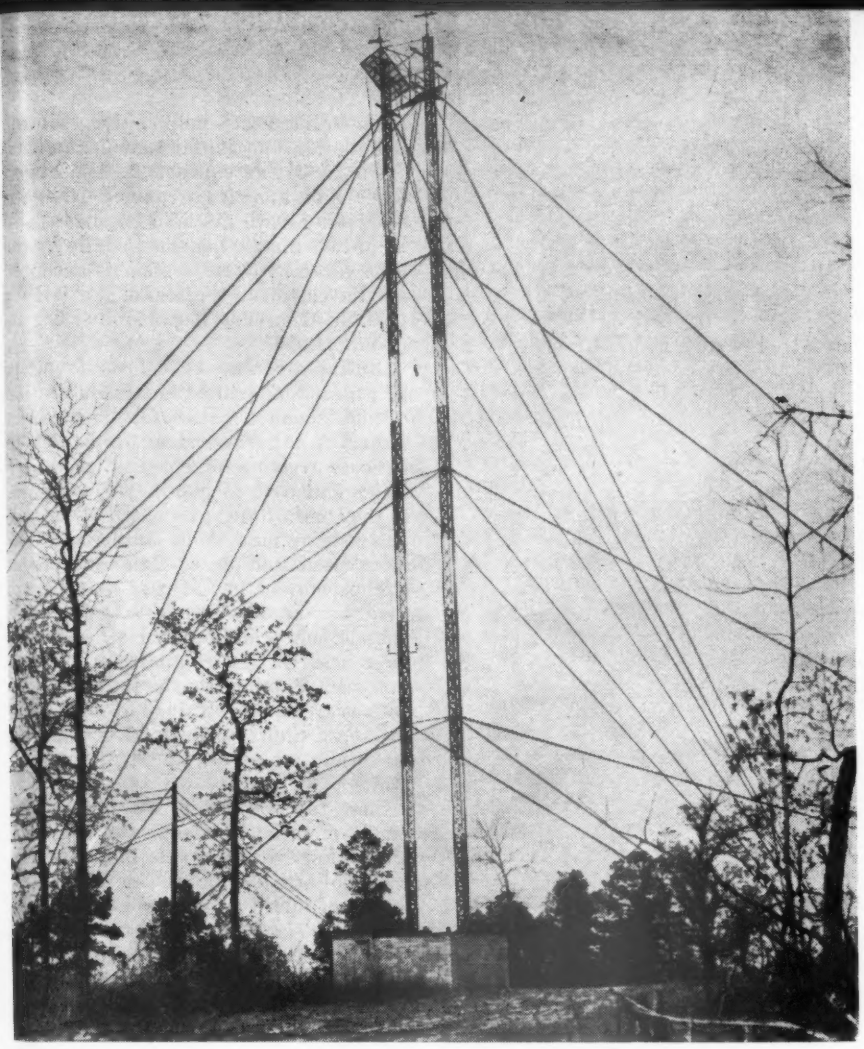
Materials

In repiping Tennessee's gas compressor stations to the system outlined, all pipe fittings, valves, etc., subject to high pressure gas were installed to conform to the ASA B31.1 Code for Pressure Piping, to Division 1 standards of Section 2 of the code, or better, where materials were obtainable. For plants operating at 760-psi discharge all large diameter high gas pressure gas pipe in the plant yard was either installed or relaid to the following diameters and wall thicknesses: 24-in. by ½-in. wall thickness; 26-in. by ⅝-in. wall thickness; and 30-in. by ⅞-in. wall thickness. As the production pipe mills do not normally make pipe in wall thickness greater than ½ in. in these sizes, it was necessary that a considerable portion of the pipe be manufactured by fabricators. This pipe being nonexpanded, was all stress relieved and hydraulically tested. A new line of fittings was designed and manufactured to make the required connections possible. All materials in both the pipe and fittings were at least 42,000-psi minimum yield material and all wall thicknesses were specified as minimum rather than nominal in order to obtain full strength throughout all fittings and pipe.

Construction

Isometric drawing of Tennessee's compressor station No. 8, near Batesville, Mississippi, is included to show an actual plant piped by this method. All of Tennessee's plants have been repiped to this system and the blow-down remote control system installed within the last two years. A small amount of lightweight pipe and some welding saddles remain to be removed and replaced with specification material. The remaining portion of this work will be completed in the 1952 construction season; however, all basic elements of the manifold system are now installed.

For initial pipe line construction and the first compressor building installation it is not necessary to install the four pipe lines across the plant yard, but just that portion that will carry out the required design considerations. The series of sketches, Fig. 5-A through Fig. 5-C show various steps in which this system may be constructed, but will cost considerably less by the time it has reached a size of three pipe lines and three compressor buildings. ★ ★ ★



One of Mid-Valley's microwave repeater station near Hallsville, Texas.

Microwaves in Operation

What are the operating problems encountered on a long microwave system and how are they being met?

CARL A. COMPTON

As late as 1950 microwave was often referred to as the "last frontier" of unused spectrum space and was expected some day to provide voice communications from one end of a pipe line to the other. The realization of that dream came about much faster than many people believed possible. Today there are several short systems and a few long systems approaching or exceeding 1000 miles in length that are providing not only economical and reliable voice communications but teleprinting, telemetering, and supervisory control services as well. The rapid strides made in the last two years in this new field have opened up new vistas and introduced some new concepts of pipe line communications. Companies considering the installation of a communications system have learned that the first cost of a microwave system is considerably less than that of other types of systems provided that the circuit requirements exceed a minimum number (variously estimated at four). Companies, however, have little else, other than manufacturers' claims, on which to base their determination of probable operating costs or expected degree of reliability in a long microwave system. It is not the purpose of this article to compare equipments or, for that matter, to indulge in a discussion of the technical problems associated with operating a microwave system. It is thought, however, that an enumeration of some of the general operating problems encountered on a long microwave system and how they are being met will be of interest and possibly of some benefit to those either considering the construction of a new system or about to take over the operation of a new system.

A problem that confronts an operator at about the same time that equipment is being selected is that of choosing maintenance personnel. Future operating costs and degree of system reliability will, in a large measure, depend upon the wisdom used in the selection. Federal law requires that a microwave technician possess at least a second class radio-telephone operator's license. The holder of such a license who has a good background in the practical maintenance of electronic equipment, particularly VHF communications equipment, is a likely prospect as a microwave technician. His capabilities are further enhanced if he is or has been an amateur radio operator. People with considerable experience in the maintenance of telephone carrier equipment should have little trouble in mastering microwave maintenance techniques. In addition to his technical qualifications, a prospective technician should possess an inquiring mind, a spirit of cooperativeness, and an ability to work with others. He is not a person working alone with a discrete amount of equipment, but a member of a maintenance team. In a long microwave system some troubles have a habit of showing up at points quite remote from the source. In such cases it is necessary that there be a free exchange of information and assistance among the team members.

Most manufacturers provide, as a service to their customers, an intensive factory training course designed to familiarize the technician with the manufacturer's product and to give him practice in the tuning and adjusting procedures. After completing the factory schooling, the technician should be afforded the opportunity of working with

The Author

Carl A. Compton is communications supervisor for the Mid-Valley Pipeline Company, a position he has held since October, 1950. Born in McLeansboro, Illinois, January 7, 1915, he joined the Research and Development Department of the Sohio Pipeline Company in St. Louis, Missouri, in 1947, where he specialized in communications and river radar applications. He joined Mid-Valley when that system started operation.

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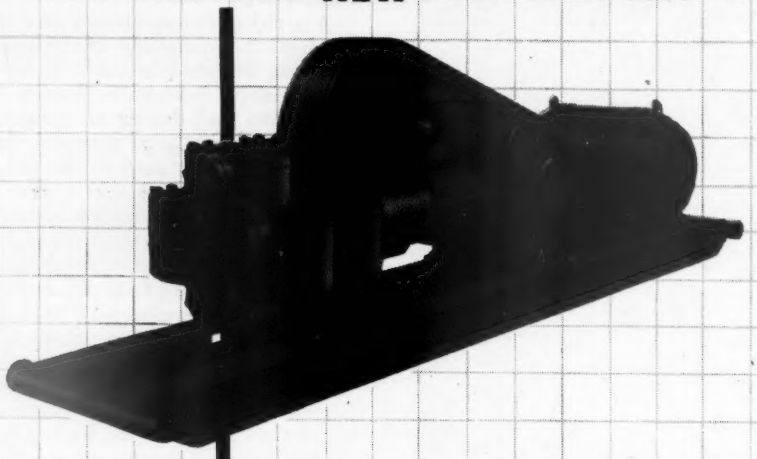

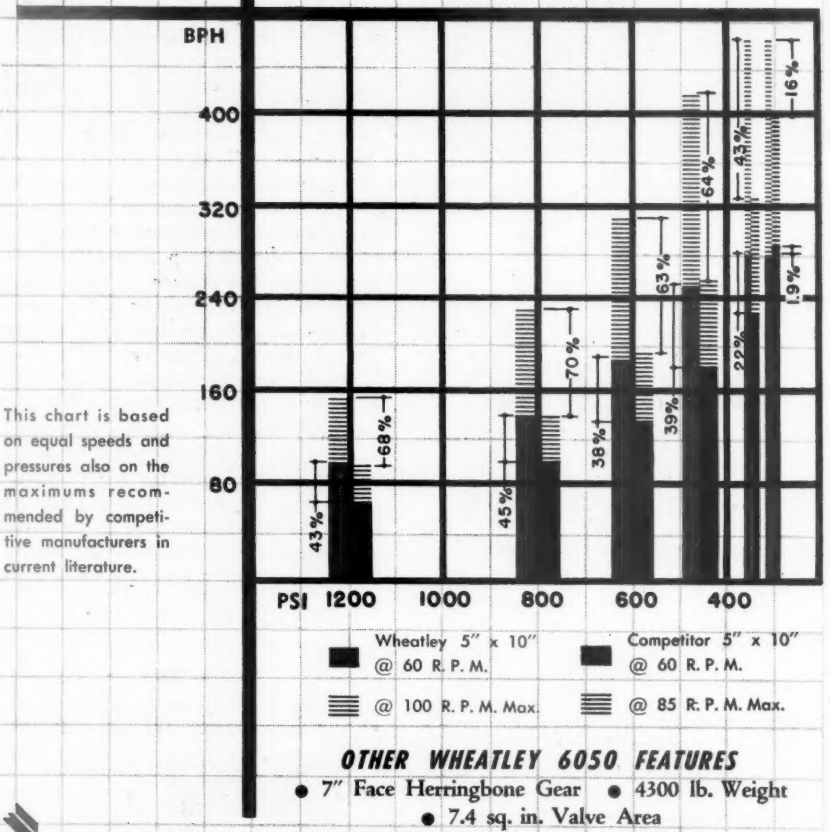

This chart is based on equal speeds and pressures also on the maximums recommended by competitive manufacturers in current literature.

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the manufacturer's field engineers in the installation and initial tune-up and adjustment of the equipment. The experience and knowledge gained from his association with the field engineers will be of inestimable benefit. Usually by the time the microwave system is accepted by the customer the technician is in a position to accept responsibility for its maintenance.

Business coupes have been found to be a practical vehicle for transportation of maintenance personnel. Their light springing affords extra protection to delicate test equipment and good visibility and ease of handling contributes to the comfort of the technician who will be spending many hours in driving. The more often used pieces of test equipment can be stowed in the rear deck where they are readily available, and spare chassis, tubes, and other small parts can be carried in the compartment behind the seat. Another consideration is that coupes are not constrained to stay within the speed limits set up for trucks nor to avoid city streets where trucks are prohibited.

Some are no doubt wondering how much work can be assigned to one technician. Experience to date indicates that one qualified technician can, in a 40-hr week, maintain a system efficiency of 96-98 per cent in a 250-mile section with station spacings averaging 30 miles. This efficiency has been realized on a system equipped with duplicate RF equipment and auxiliary electric power generators. As a goodly portion of a technician's time is spent in driving, station spacing and accessibility, and the character of the roads between stations, will have considerable bearing on how much equipment a technician can handle. It has often been remarked that one man could maintain a 1000-mile system if it could all be placed under the same roof.

Along these same lines, it is often possible for other company employees to save the technician many hours by giving a few minutes of their own time. Anything that can be done to reduce to a minimum the amount of time expiring between the discovery of an outage and the technician's arrival on the scene is well worth while. For example, it has been determined that pump station personnel can, by means of some simple tests, bracket an outage between adjacent pump stations. Some of them, with a little instruction, can learn to use outage locating equipment. As pump station personnel are usually the first to become aware of an outage, the information that they can gather and pass on to the technician may save considerable down time. Pipe line maintenance personnel are charged with performing some of the maintenance at the radio stations. It is their responsibility in the event of a rash of power failures occasioned by storms, to keep the auxiliary fuel tanks filled with gasoline and to keep the engines in excellent repair at all times. Proper operation of the auxiliary generators saves many hours of outage time in some areas.

The problem of keeping watch over tower lamps can be handled by enlisting the aid of people outside the company living in the vicinity of the lighted towers. These people observe the lamps each evening and mail a postal card report to the technician's headquarters. In an emergency requiring notification of the CAA, they are instructed to report immediately by telephone to the nearest pump station from which point the contact with the CAA is handled. Another possible method of handling the problem is mentioned below.

More aids to technicians are available in the form of system gadgetry. Alarm generators and receivers are variously used to provide remote indication of auxiliary generator operation, switchover to standby RF equipment, and tower lamp failure. The alarm receivers, to be effective, should be installed where they will be under constant surveillance of operating personnel. They are straightforward enough in operation that pump station operators can use them and pass along the information that will often permit a technician to forestall an emergency before it occurs. No experience has been had so far with tower lamp failure indicators; however, serious consideration is being given to such an installation because it appears that a more reliable and economical operation will be obtained.

There are several factors other than the selection of the microwave equipment itself that will have an important bearing on system reliability and maintenance cost. For example, if the load transfer switch on the auxiliary power generator is not infallible in operation, installation of standby power generating equipment is useless and, in some cases, a distinct disadvantage. Duplicate RF equipment is of no value unless the sensing and switching relays are certain in their operation. It may seem odd that failure of standard switching equipment, relays, etc., that have been in wide use for years should result in such a disproportionate amount of outage time. It is true, however, that outages resulting strictly from electronic difficulties are extremely rare in the system with which we are acquainted.

Experience indicates that the proper place for auxiliary generator fuel tanks is buried in the ground outside the equipment shelters. Gasoline left standing for a considerable length of time in aboveground tanks will lose some of its higher ends through evaporation and will also become contaminated with water as a result of moisture condensing inside the tank. Tanks on elevated stands inside the equipment shelter also present a fire hazard in the event of a lightning strike or a leaky fuel line.

With one possible exception, no outage time has been experienced on the system previously referred to as a result of vandalism. No special precautions were taken other than to enclose the equipment inside an 8-ft high concrete block wall. Other than losing a few

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tower lamps by .22 rifles, no serious damage has been incurred.

Another suggestion having no direct relation to improving system reliability but one that will often ward off unjust criticism of the equipment is that of installing howlers and loud ringing bells in pump stations to attract the attention of operators who may be working some distance away from the telephone instrument. Operators are sometimes prone to report a system failure when, actually, a high noise level in the pump station prevented the called party from hearing the ringing of the instrument.

As to the performance of a long microwave system, amazing results have been obtained insofar as voice quality is concerned. We believe that the quality is as good as and, in many instances, better than that realized in other means of communication. With proper selection of accessory equipment, there is no reason why the reliability of a microwave system cannot approach very close to 96 or 98 per cent. The recent tornadoes through the southwestern part of the country caused very slight damage and no loss of system continuity on at least two long microwave systems with which we are acquainted. In some areas, they were the only means of communication after the passage of the storm.

Because of narrow beam propagation characteristics, they are virtually free from the type of interference associated with VHF radio systems. There are some night time fades but the operator will rarely be conscious of them. It is seldom that a fade is deep enough to cause loss of a circuit and even then it is usually only for a second or two.

Much has been said and written about tube life in microwave equipment. There is no basis for arguing that tube life in microwave equipment is not as great as it is in any other electronic equipment. If voltage regulating transformers are used, the indications are that tube life can be further extended. Klystrons have been found to have a much longer life than the manufacturer guarantees. There are klystrons in microwave equipment today still giving good service after two years of operation and there is no reason to believe that they will not continue to do so for another two years or longer. A representative tube replacement cost for one year at a repeater station is $60. Power costs at the same station will average $25 per month.

The reader has by this time no doubt gained the impression that we are sold on microwave as a means of pipe line communications. To point up how true this is, one of our operating superintendents was heard to remark the other day that microwave is the greatest boon to pipelining since welded pipe. We believe that if Horace Greeley were around today in the role of a communications consultant, his advice would be, "Buy microwave, young man. Buy microwave." We further believe that those who followed this advice would finally be forced to admit that (to borrow an expression from a Texas colleague of ours) "they never had it so good". * * *

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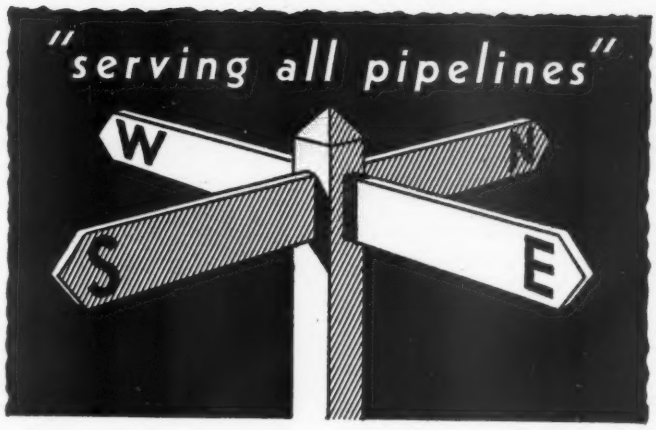

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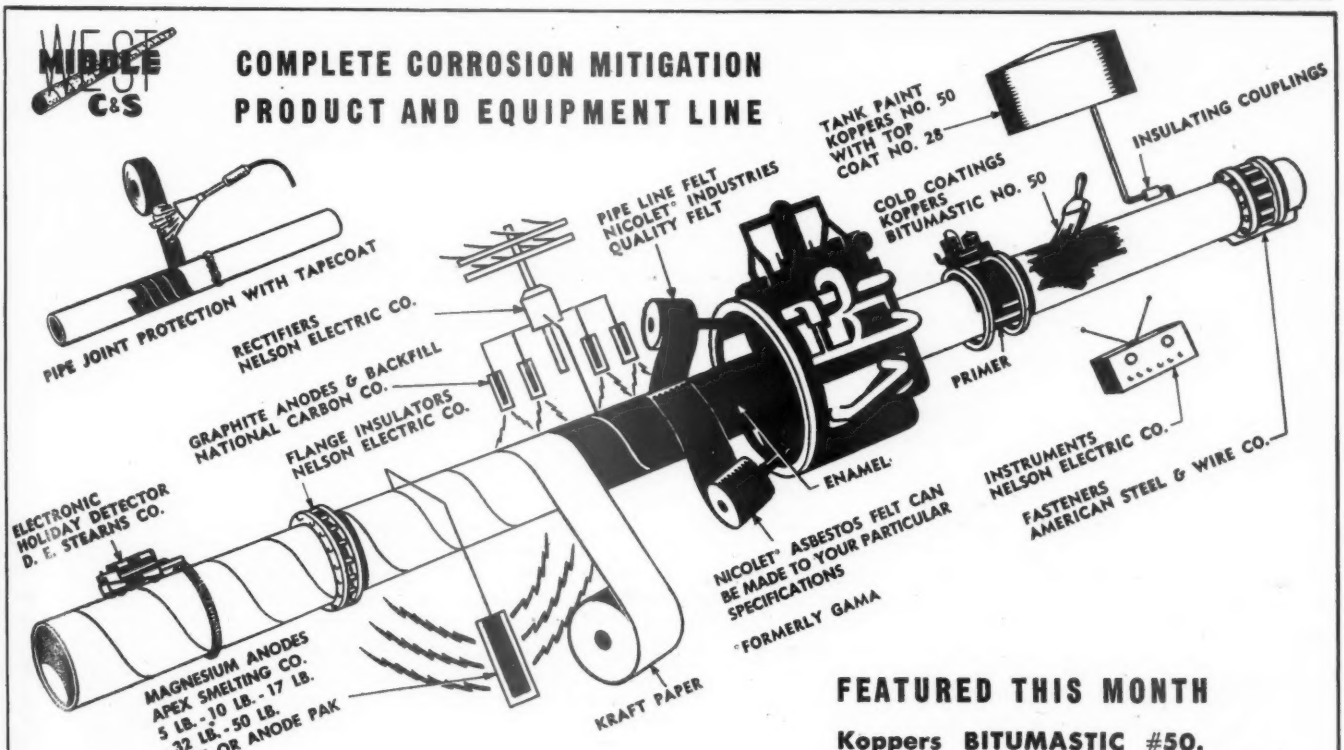
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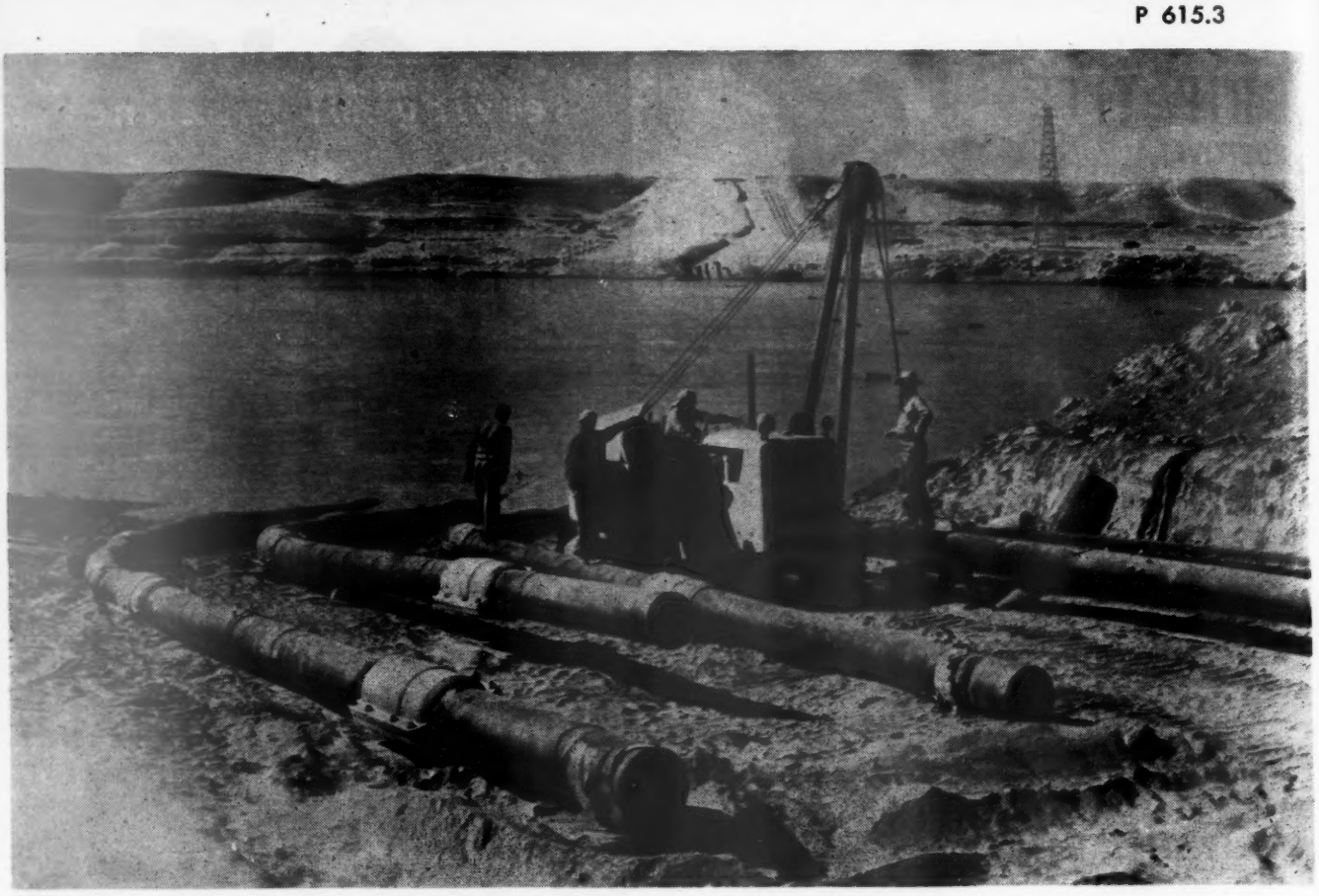

Major river crossings were the Tigris (500 ft) and the Euphrates (1400 ft) on the 556-mile Kirkuk-Banias 30-32-in. pipe line. Four 16-in. lines were used for the river crossings. The Euphrates crossing is shown here, with all 4 lines ready to be tied into main line.

KIRKUK TO BANIAS PIPE LINE

New large diameter line across Iraq and Syria will increase free world's oil supply by more than 300,000 bbl a day

RICHARD FINNIE

FINISHING touches have now been put on another of the world's great crude oil pipe lines in the Middle East. Half as long as the Trans-Arabian pipe line system, which extends 1068 miles from Abqaiq, Saudi Arabia, to the Mediterranean port of Sidon, Lebanon, the new pipe line is comparable to it in diameter and capacity, with many similar construction problems.

The town of Kirkuk is situated in the northeastern corner of Iraq, and nearby is the center of a great oil field developed by the Iraq Petroleum Company, Ltd. Oil was discovered near Kirkuk in 1927, but beyond the reach of memory there had been on the surface of the earth hereabouts a visible clue to the riches beneath — natural gas seepage that was burning before the reign of King Nebuchadnezzar. This was the traditional Fiery Furnace of Shadrach, Meshach, and Abednego.

In the early 1930's IPC constructed two 12-in. pipe lines to bring crude oil from Kirkuk to the Mediterranean Coast. Some 50 miles southwest of Kirkuk the pipe lines crossed the Tigris River. Here the first booster pump station was installed. The route now traversed the desert that was once the rich heartland of Mesopotamia, between the Tigris and the Euphrates. Eighty-four miles southwest of the Tigris, the pipe lines crossed the Euphrates. On the west side there was another pump station. Then the lines forked, one going to Haifa, the other to Tripoli.

There were five pump stations on the southern branch, and four on the northern. Each had its own airfield and accommodations for a permanent staff of European and Arab technicians.

Another set of lines of 16-in. diam was laid later, but the southern branch to Haifa was sealed off by the conflict in Palestine in 1948.

The northern branch cut across the Syrian desert, following one of the great

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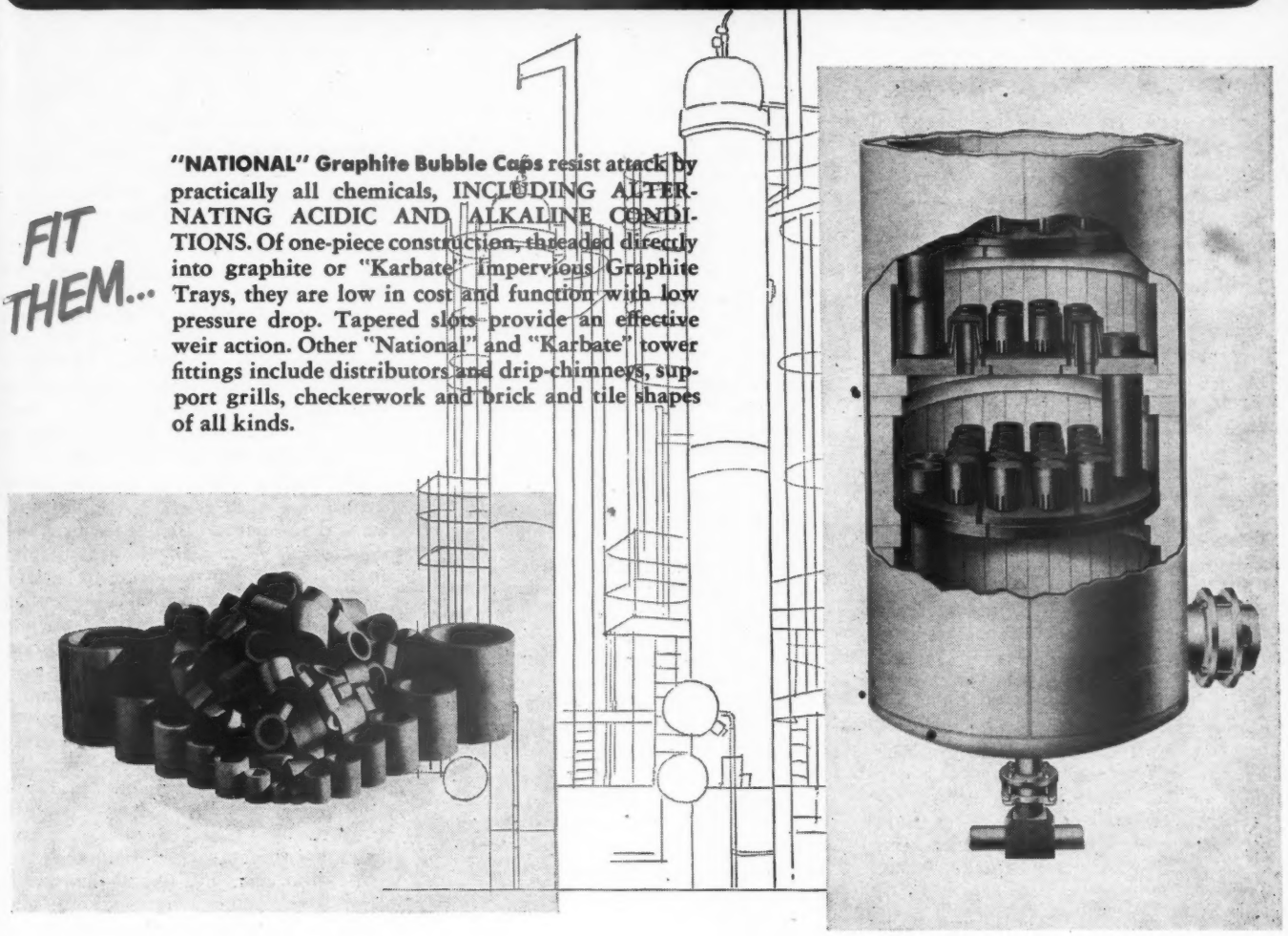

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trade routes of antiquity between Egypt and Persia. Here in the middle of the desert the line passed the ruins of Palmyra, a city that flourished more than 2000 years ago as a center of culture and commerce.

The 12 and 16-in. lines had their outlet at Tripoli, on the Lebanese coast of the Mediterranean, 535 miles from Kirkuk, delivering as much as 160,000 bbl a day of crude oil to tankers lying offshore. The old city of Tripoli changed little outwardly, but its people gained new prosperity through the operations of the oil company.

In 1947 the Iraq Petroleum Company decided that a new and larger pipe line should be laid from Kirkuk to the Mediterranean, paralleling the existing northern lines to a point near Homs, then striking the coast at Banias, Syria, about 60 miles north of Tripoli.

Meanwhile, across the desert of Saudi Arabia the thousand-mile-long Trans-Arabian pipe line system was being laid from the Persian Gulf to a Mediterranean outlet in southern Lebanon. It was the greatest oil pipe line project ever undertaken, and the builders of the major portion were forces of the Bechtel interests — engineers and constructors long accustomed to doing tough jobs quickly and efficiently in far corners of the world including the Middle East. Before the completion of the Trans-Arabian pipe line at the end of 1950 the new IPC project was getting under way, and Arabian Bechtel Company was chosen as the prime contractor.

As on other Bechtel jobs in the Middle East, only a few Americans were employed—all specialists in pipe line engineering or construction. There were 50 Americans all told, in the offices and in the field. About 200 Britishers were recruited through George Wimpey and Company, Ltd., in the United Kingdom.

The Author

Enjoying the unusual position of historian with Bechtel Corporation, San Francisco, and its affiliates, Richard Finnie is the author of a number of books and many magazine articles. During the past few years he has commuted from Alaska to the Gulf of Mexico and from California to Saudi Arabia, Iraq, and Syria to cover outstanding construction projects in word and picture. He is now putting the finishing touches on a documentary film record of the Kirkuk-Banias pipe line told about in this article.

The policy was to employ and train as many local people as possible. Ultimately there were 2500 Arabs on the direct payroll, and an equal number working for local labor subcontractors.

The first base camp was established at the outskirts of the city of Homs, Syria. All-weather portable huts, each accommodating four men, were erected. Some of these were Swedish prefabs, others were Supalite huts from Britain. Besides the living quarters there were a mess hall, laundry, recreation hall, office building, and garages and shops for the maintenance of equipment.

In a field a mile away from the camp the ground was graded and storage racks and skids were prepared for pipe shipments, while special equipment of many kinds was received at a rail siding in the neighborhood. There were compressors, welding generators, and massive sideboom tractors. And there were 250-hp trucks, manufactured in England, for hauling pipe and heavy freight. Nearly 700 pieces of large equipment were needed.

Hundreds of Arabs were hired to put down a solid foundation for new stretches of access road along the right-of-way, and they used the technique of their ancestors who built roads through the same country for the Romans. New right-of-way had to be cleared of rock and smoothed. Although east of Homs the new pipe line would parallel the old ones, it had to be laid a full 15 ft away.

Cranes, shovels, and draglines were assembled along the right-of-way, and British and American mechanics worked side by side. It was a red-letter day when the first backhoe bit into the soil and rock of the IPC right-of-way. This backhoe and other excavating equipment had to make a ditch 556 miles long—a matter of about 2,000,000 cu yd or nearly 3,000,000 tons of earth and rock.

The highest elevation on the entire route was 2537 ft at a point 90 miles inland. From there to Banias the pipe line would be 26 in. in diam for gravity flow, and this was the first portion to be laid.

Between Homs and Banias lay a plain bordered by hills, where the land had been cultivated for many centuries. Northward along the coast ran a road on either side of which were olive groves. The hillsides were terraced so that every foot of ground could be made productive. Just off the coast, near the town of Tartus, the pipeliners could look upon the Island of Arwad, continuously occupied by Phoenician seafarers and their descendants for thousands of years. And near by, on the mainland, stood stone columns erected over the tombs of Phoenicians who died in the forgotten past.

Among the hills approaching the Mediterranean along the pipe line route were other more recent landmarks of history. These were the Crusader castles that saw Richard the Lion Hearted and Saladin contesting for the field some eight centuries ago.

The pipeliners set up a line camp near Tartus, which was centrally placed. But before they got fairly started the rains came. Photographs in monthly progress reports illustrated the pipeliners' struggles against rain and mud and frost. But at last the land dried out and the job went forward at a faster pace.

Arabs, Britons, and Americans worked together. All but the most highly specialized tasks were performed by Arabs, trained and directed by their American and British friends. The British, too, who were newcomers to the craft, learned much about pipelining from the Americans.

In rocky terrain hundreds of local laborers were employed to clean out the machine-dug ditch and cushion it with screened earth and gravel. These people came from the farms and villages in the

Unloading of 30-32-in. pipe from *Pacific Nomad*, Tripoli. Note nested joints.

districts through which the line was being laid. As soon as the work was finished in one district, new gangs of laborers would be hired and the old ones paid off. This was in accordance with the wishes of a government-sponsored labor syndicate, to spread the employment of unskilled workers as fairly as possible.

After the floor of the ditch had been padded, cleaning and priming machines were sent over the line, scraping off rust and scale and applying a coat of primer. Next came the coating and wrapping machine, putting on a double coating of coal-tar enamel and a double wrapping of glass fiber and asbestos felt. Now the coated and wrapped pipe was lowered into the ditch. Soon it would be carefully covered over, ready to begin its long years of service. This 26-in. pipe, 23,000 tons of it running inland 90 miles, came from the National Tube Company in Lorain, Ohio.

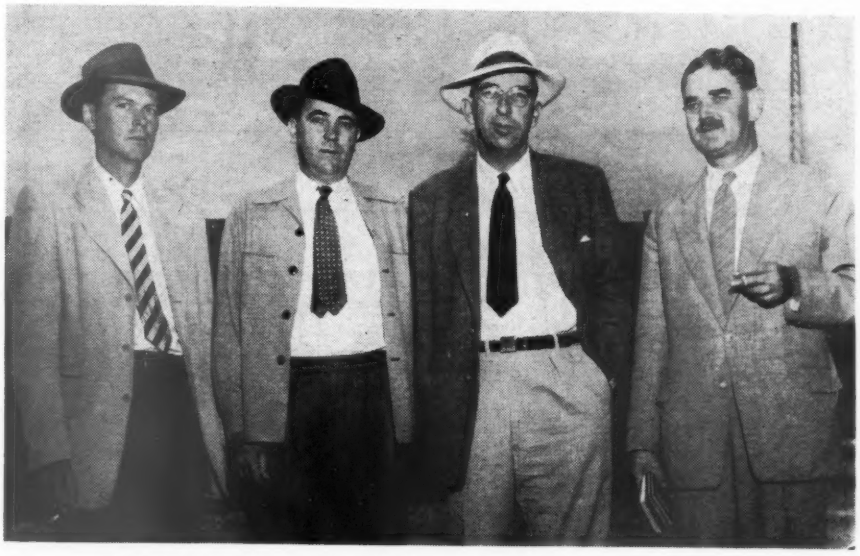
Meanwhile, in a plant of Consolidated Western Steel Corporation near Los Angeles, still larger pipe for the bulk of the Kirkuk-Banias line was being fabricated. Steel plates were run through massive rolls that turned them into cylinders 31 ft long. Then the cylinders were longitudinally welded inside and out by automatic machines. The cylinders were tipped into hydraulic expanders that made them perfectly round and straight and stretched the steel to increase its tensile strength. The ends were beveled for field welding. The joints were given a final inspection and rolled down skids to a railroad siding.

The pipe joints were fabricated in two diameters so that they could be nested, one inside another, to conserve shipping space and cost. This ingenious device had been used with the pipe for the Trans-Arabian line, which was 30 and 31 in. in diameter. The pipe for the Kirkuk-Banias line was 30 and 32 in. Each nested pair of joints weighed as much as four tons.

From California the 30-32-in. pipe, 160,000 tons all told, was carried halfway around the globe in 27 shiploads. Two-thirds went through the Panama Canal and across the Atlantic and the Mediterranean to Tripoli. The remaining third went through the Persian Gulf to Basra, and thence by rail to Baiji, near the first booster pump station out of Kirkuk. The pipe sent to Baiji was to fill in the eastern end of the line.

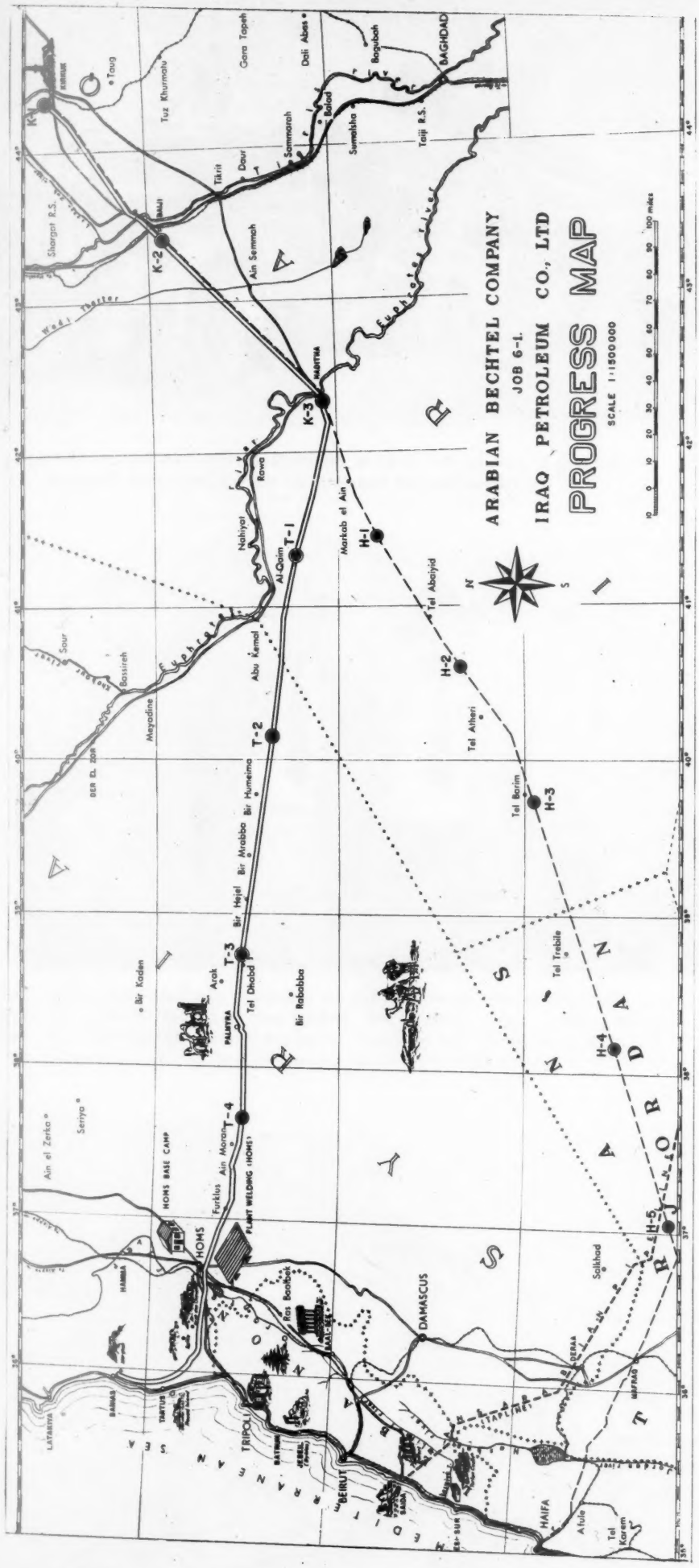
It was from the Mediterranean end, however, that most of the line was laid. Ships carrying pipe for the western portions dropped anchor a mile offshore from Tripoli, which was as close as the depth of water and port facilities allowed. Assorted freighters were used for the transportation of pipe, but Libertys proved to be the most satisfactory and carried about two-thirds of the total

Stringing of pipe for the 30-32-in. Kirkuk-Banias crude oil line constructed by Arabian Bechtel Company for the Iraq Petroleum Company, Ltd.



Some of the men responsible for the success of the Kirkuk-Banias pipe line project. Left to right: James Leaver, project manager; Clark Rankin, executive vice president; John M. Rogers, president, Arabian Bechtel Company; and Frank O'Connor, resident engineer, Iraq Petroleum Company, Ltd.

Denesting of 30-32-in. pipe at Homs.



tonnage. One of these ships could carry 18 miles of the big pipe.

All lightering was done by local stevedores with local barges and tugs. The nested pipe joints were transferred by crane from barge to railroad car. Dinky though the old European-type cars looked by comparison with modern American cars, they were sturdy and could safely hold ten nested joints apiece. Day after day trainloads of pipe moved from the port of Tripoli in Lebanon to Homs in Syria, 60 miles to the northeast.

The immediate destination of the freight trains was the yard near the Homs base camp of Arabian Bechtel Company, where the pipe was to be processed and stockpiled before being delivered to the right-of-way. Here a remarkable production line was in operation for the triple-jointing of pipe. It was one of the keys to the success of the whole Kirkuk-Banias project, a system developed by Bechtel engineers, cutting down by two-thirds the amount of manual welding to be done on the right-of-way.

Having been unloaded from the rail cars, the pipe sections were rolled and shunted to a denesting apparatus. This machine gripped the inner pipe while the outer one was drawn away from it. The 30 and 32-in. pipe joints were now dealt with separately. An automatic, electrically driven clamp rolled into each joint to line it up exactly with another. Stringer bead and hot pass were applied by hand. The same procedure was followed with a third 31-ft joint, so that now there was a solidly united combination 93 ft long. Each 93-ft section was fed through a shack in which two additional passes were made by an automatic welding machine. This was a shield-arc type that had first been adapted for the Trans-Arabian pipe line project. It completed five welds per hour, and every weld was uniform.

From the stockpile being built up in the Homs pipe yard, the 93-ft sections were loaded onto the heavy truck-trailers that would carry them out over the desert to wherever they were needed along the right-of-way. Nine pipe sections made up a full load, weighing as much as 54 tons.

It was an endless task to keep in repair all mobile equipment, especially the huge pipe-carrying trucks. There were 35 of them and they required frequent overhaul at the Homs base camp.

As the pipe line was pushed farther out over the desert, new camps were set up for the construction crews near the existing pump station communities, averaging about 70 miles apart. The portable houses that had first seen service at Homs were extensively used at the line camps. But at some of the camps the portables were supplemented by houses made of local materials. Working with adobe bricks, Arab masons could erect a dwelling in almost as short a time as it took to bring a portable from Homs. A few of the buildings were of stone, and these were assembled with

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Lowering in west of T-2. Kirkuk-Banias pipe line.

equal skill. The interior walls were smoothly plastered with a burnt calcium mixture obtained in the neighborhood.

The two fabulous life-giving rivers of the desert, the Tigris and the Euphrates, had to be spanned by multiple lines rather than just one to guard against any interruption of service. The Tigris, whose width at low water was 500 ft, was dealt with first. Next came the Euphrates, 1400 ft wide.

Transportation back and forth across the river was maintained not only by motorboat and ferry but also by an extraordinary overhead cableway system erected by IPC. This was a permanent installation designed for the speedy ferrying of automobiles. The machine picked up car and passengers together with a slender but strong wire rope and whisked them to the other shore.

In advance of the main pipe spread, a little band of Americans with their Arab helpers got equipment together, rigged up a cable and proceeded to pull the first of four 16-in. lines across the Euphrates in October 1951. It was a delicate operation, calling for precise coordination of men and equipment. On the east side of the river the line was held aloft by sideboom tractors. A signal flag was raised. The tractors moved forward. At the same time, the cable attached to the pipe was drawn through a pulley by tractors on the western shore. It didn't look so very difficult; but weeks of painstaking planning and a great deal of improvisation lay behind the pulling of that first line. A few days later all four of the 16-in. lines lay firmly on the river bottom, and their ends were ready to be tied in to the main pipe line.

All this time the ditch was being extended ever farther across the desert from the Mediterranean. Where the ground was not too tough, a ditching machine cut an even swath 4 ft wide and 5 ft deep, but roughly 80 per cent of the ditch had to be opened up in rock, and this called for blasting. The broken rock was cleaned out by a backhoe, but

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hand labor was brought to bear to smooth the bottom of the ditch and pad it with screened earth to receive the pipe.

Well-trained crews unloaded the pipe and strung it along the right-of-way. Then came the pipeliners in two spreads, lining up and welding, mile after mile. An automatic, electrically driven internal clamp brought each 93-ft section of pipe into alignment with the next one. Veteran American welders applied the stringer beads. The hot passes and fillers were made by men from the United Kingdom. They were less experienced than the Americans but soon gained proficiency and did a thorough job. The welders' helpers were Arabs, and so were most of the tractor operators.

The pipe came in two thicknesses, 3/8 in. and 7/16 in., depending on the pressures it would have to withstand in service. The two diameters were of course used separately. The 30-in. pipe was placed at the discharge side between pump stations where the pressure would be greatest. The 32-in. pipe was placed at the incoming side where the pressure would slacken.

Behind the welders came the doping crews, first with cleaning and priming machines. There were two machines. One of them scraped off rust with a battery of knives. The other was fitted with wire brushes to remove any residue of rust and mill scale before it applied a coat of coal-tar primer. The painted pipe was dusted by hand to ready it for the next operation.

Coating and wrapping machine on the IPC Kirkuk-Banias pipe line. The line was double-coated with coal-tar enamel and double wrapped with glass fiber and asbestos felt.

Now came the coating and wrapping machine, whose performance was complicated and spectacular. While the pipe was suspended in roller cradles from sidebooms, the machine slipped along under its own power doing four things at once. Hot coal-tar enamel fed through a hose from a mobile kettle was flooded

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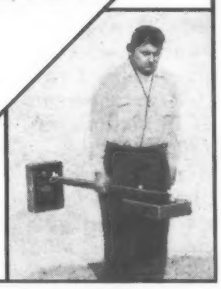

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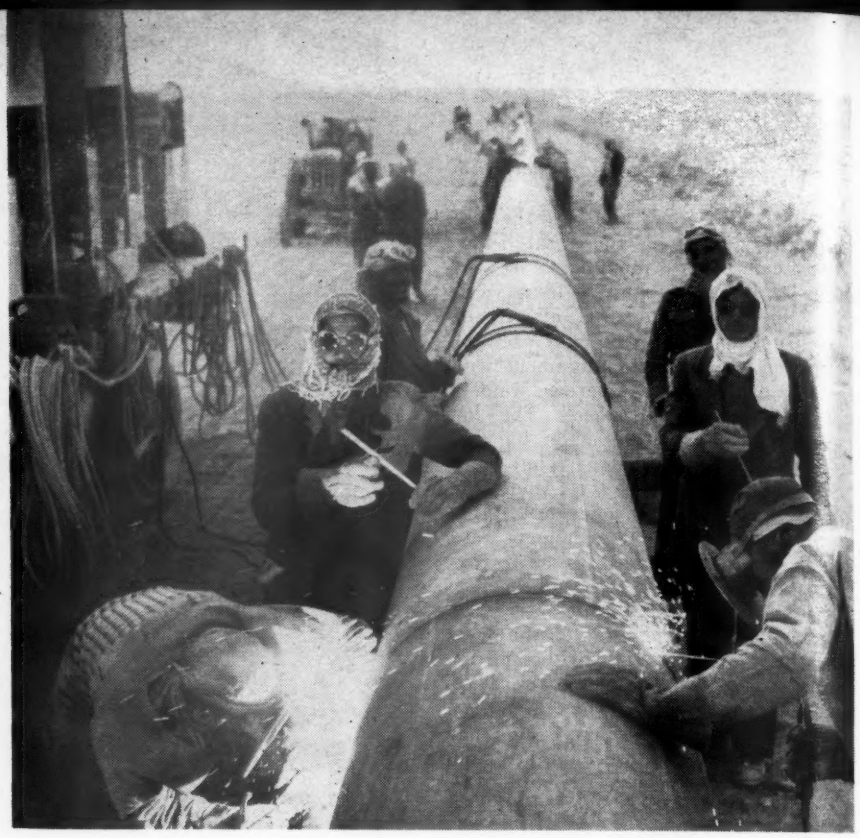

Stringer-bead men and Arab helpers on IPC line west of T-2.

over the pipe. A band of glass fiber for reinforcement was rolled on. Over the glass fiber went another coating of coal-tar enamel. And, finally, a band of asbestos felt enclosed the pipe. It was the first time that a big-inch long-distance pipe line had been given a continuous double - coat, double - wrap, treatment with hot coal-tar enamel.

With a total thickness of a quarter of an inch of insulation, the pipe was well protected against corrosion underground.

A holiday detector was then passed over every foot of it to warn against the slightest break in the coating. Extra coal tar and asbestos felt were put on by hand wherever the insulation was disturbed in the wake of the machine.

Now the pipe was ready to be lowered into its trench. The heavy sideboom tractors carefully raised the pipe with wide slings. Supporting timbers were removed. Like the conductor of a symphony orchestra, a foreman directed the players and synchronized the instruments. Gently, the pipe came to rest on the floor of the ditch, which had been smoothly padded.

Before the line was completely backfilled, gangs of Arabs with hand shovels and screens put down a 6-in. protective layer of soft earth over the sides and top of the pipe.

All along the route the winter of 1951-52 proved to be the most severe in the memory of the oldest inhabitant. Rain, snow, frost, and mud hampered progress. Freighting of supplies and pipe was constantly difficult. The doping of pipe was often held up because of rain or frost. Such problems notwithstanding, the line was ready for commissioning in April this year, almost exactly 18 months after ground-breaking and 6 months before the date scheduled for completion.

The work of Arabian Bechtel Company for the Iraq Petroleum Company. Ltd., was carried out under the overall direction of Van W. Rosendahl, chairman of the board, and John M. Rogers, president. Continuous, on-the-spot supervision was given by Clark Rankin, executive vice president, with James Leaver as project manager, assisted by A. M. Berlander. Roland J. Ross was administrative manager, and Harry F. Waste, project engineer. The general superintendent of pipelaying was Roy C. Middleton. Joe James was superintendent of Spread No. 2.

While Arabian Bechtel Company crews were filling in the remaining gaps in the big pipe line, the Iraq Petroleum Company put up a tank farm for storage of the oil at Banias. And there, also, were submarine lines beneath the waters of the Mediterranean, waiting to load tankers bound for Western Europe.

The 556-mile pipe line from Kirkuk to Banias will increase the free world's oil supply by over 300,000 bbl a day.

It was in the Middle East that Western civilization had its beginnings. Culture and commerce attained high levels there 2000 years ago, but later went into a decline. Now, with the aid of the Westerners, who inherited and expanded the scientific and cultural knowledge of the Middle East, the modern citizens of these ancient lands have gained enormously in material wealth and in a resurgence of industrial activity based in large measure on the development of petroleum reserves that would otherwise have lain dormant for long years to come. * * *

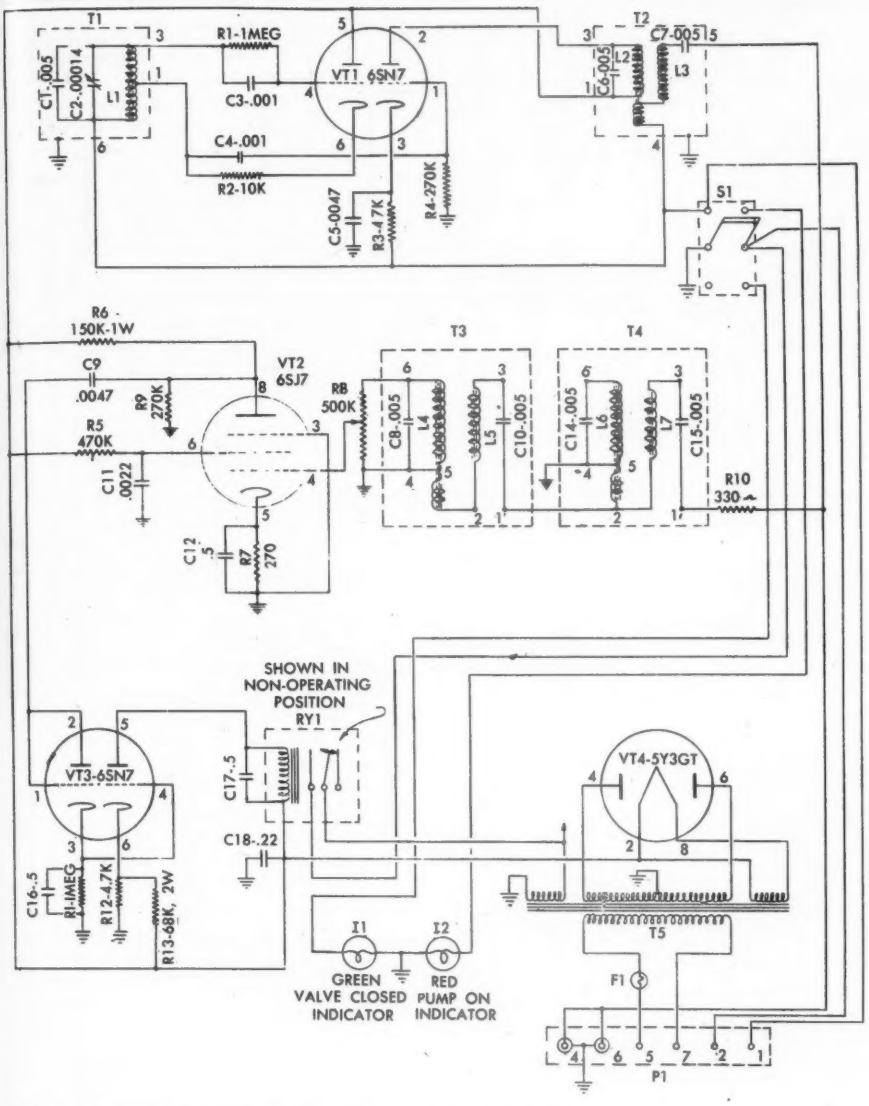

FIG. 1. Schematic wiring diagram electronic control unit.
(Resistances: ½ watt and in ohms unless otherwise stated; capacitances in microfarands.)

Pipe Line Systems Operations Streamlined

Complex pipe line and terminal facilities, resulting from a large expansion program, necessitated development of new control devices

J. R. GIESE

SUCCESSFUL operation of the complex pipe line and terminal system of Great Lakes Pipe Line Company is dependent to a great extent on use of remote controlled and automatic equipment. The practical application of equipment existing prior to the recent expansion program and development of new devices in the controls field was accomplished chiefly by the mechanical-electronics section of the company's engineering department.

Two innovations: (1) The electronic control system for motor operated tank valves and tank pumps and (2) the automatic flow controller are described later in this article. Solution of several "little headaches" of the recent expansion program resulted in other developments such as an improved automatic control of diesel, dual-fuel engine in pipe line pumping service, and a sealless direct drive through tank walls for electric gages.

Simplified Electrical Control

As the extent of Great Lakes Pipe Line expansion requirements became apparent, it was obvious that existing methods of originating pipe line shipments and controlling terminal loading would be totally inadequate.

Pipe Line Operations. Heretofore pipe line shipments of five grades of refined products had originated from relatively few tanks at normal flow rates of 6-in. and 8-in. pipe lines (14,000 to 30,000 bbl per day). Most operations were manually controlled. Sufficient time was available to permit station operators to line up the proper tanks and manifolds and give visual or phone signals when prepared for pumping. With a minimum of two lines operating from an originating point and minimum shipments of 25,000 bbl, the frequency of product changes and switches was relatively low.

The expanded system, however, was to utilize 12-in. pipe lines and handle volumes 200 per cent in excess of previous capacity. A total of 97 units of originating tankage at 16 locations was to be utilized. Many of the tanks were situated at widely scattered points throughout tank farms and at distances up to three miles from the pipe line pumping stations. The highly desirable feature of a separate supply line from each tank was precluded by the excessive distances and high cost of installing individual tank pumps. A "dictate of economics" turned out to be a single line serving one or more tank groups, each group manifolded to its suitably placed tank pump or pumps.

Transportation of additional grades

The Author

J. R. Giese, assistant to the chief engineer, joined Great Lakes Pipe Line Company in September 1947, as a field engineer during the final stages of the company's postwar construction program. After several months in the field he was transferred to the general office.

Giese was graduated from Iowa State College in 1944 with a degree in mechanical engineering. Following naval service in which he was chief engineer of a destroyer escort, he returned to Iowa State as a member of the engineering school faculty and did advance work, receiving a degree in industrial engineering.

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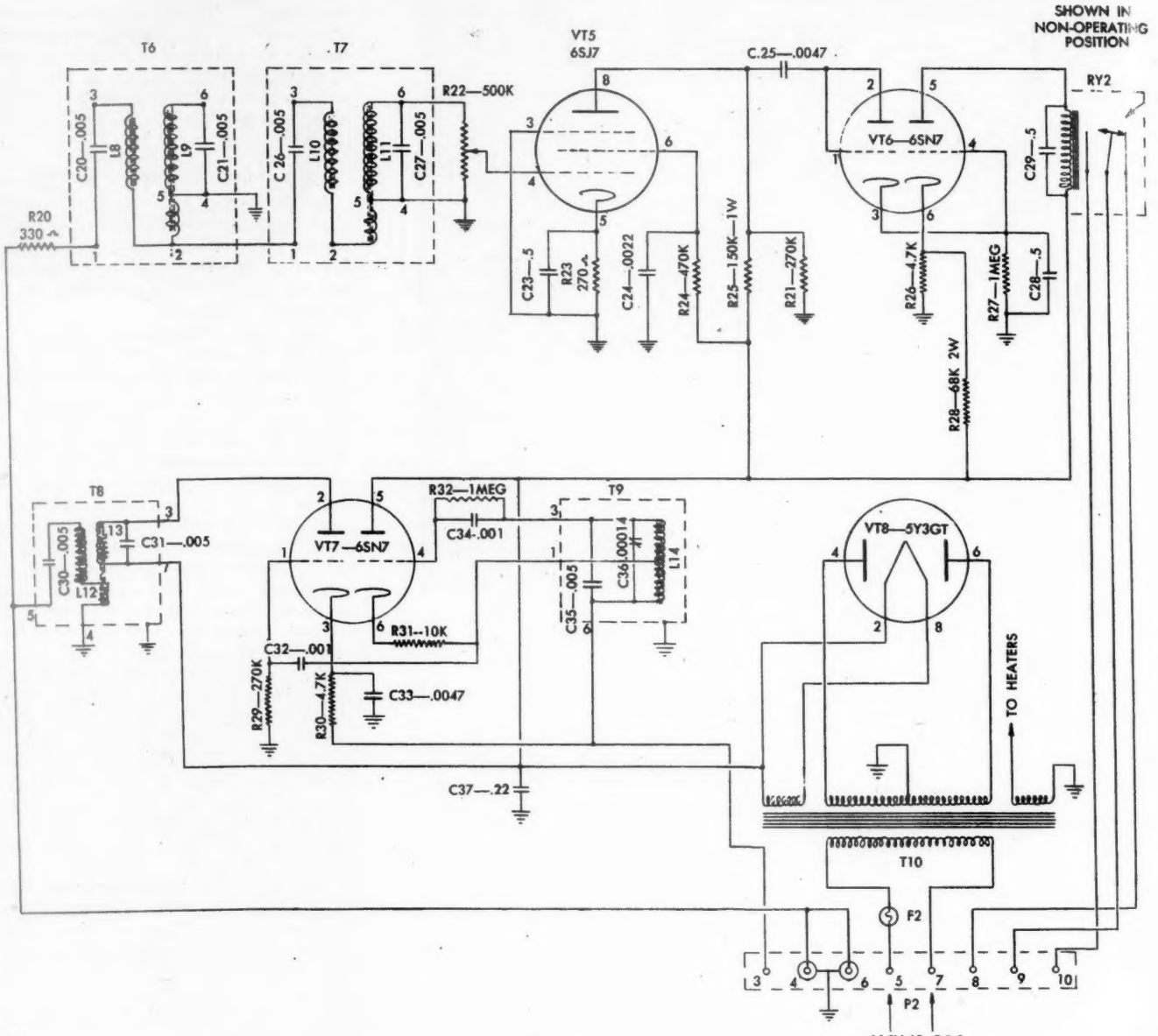

FIG. 2. Schematic wiring diagram of group electronic control units.
(Capacitances in microfarands; resistances: ½ watt and in ohms unless otherwise stated)

of refined products was anticipated. Ultimately required operation at an originating point would be the uninterrupted flow of seven different products through as many as three pipe lines. Flow rates from a given tank might vary from 14,000 to 90,000 bbl a day, depending on which of the parallel 6, 8, or 12-in. lines was to be supplied. The frequency of product changes and tank switches would increase proportionately as would the probability of their simultaneous occurrence in the multiple lines.

The exclusive manual control of proposed shipments from scattered tank facilities would have been impractical, expensive, and subject to considerable personnel error. Essential manual functions such as tank inspection and manifold alignment could be performed at a convenient time prior to scheduled pumping. But the actual starting or stopping of the tank pumps and their associated valve operations would have to be controlled from one central location, the pipe line station. Full attention of the station operator and his assistant is needed at the station during product changes or tank switching and there can be no doubt whatsoever as to the readiness of supply tanks.

Conventional electrical control circuits could handle the job, but only with considerable investment in a minimum of five wires enclosed in a buried conduit to each equipment item. A more economical solution was sorely needed.

Terminal Operations. The impending problem at larger combined station-terminal locations was even more striking. Not only was complete control of all tank pumps and motor operated receiving valves to be required at the station, but also control of tank pumps at as many as ten truck or tank car loading racks. Independent control from 11 points through parallel start and stop circuits presented a fantastic wiring scheme.

Originally, terminal loading was obtained from segregated tanks connected by common gravity lines to a centrally situated pump house. Trucks and tank cars were loaded on opposite sides of the same rack equipped to handle a maximum of five products and then only through selective spotting. Separate tanks and tank pumps were delegated to pipe line service. Resulting flexibility was poor and flow rates were limited.

Subsequent terminals built during the 1946-47 expansion employed tanks in combination line-terminal service. Each with its own tank pump, receiving line, and loading line. All functions of dyeing, circulating, loading, and pipe line boost-

ing could be performed by individual tanks. The new terminals also featured separate truck and tank car loading racks from which independent control of loading pumps was obtained through conventional electric circuits.

In order to accommodate the increased volumes from the 12-in. lines, 77 new tanks were to be erected and much of the existing tankage was to be modernized with individual tank pumps and pairs of connecting lines. Terminals scheduled for peak truck loadings of 40,000 to 80,000 bbl a day would receive four to eight truck loading units each capable of loading two trucks at once with any one of nine products.

Electronic Control System

With the above problems and requirements in mind, the Mechanical-Electronics Section brought forth a solution in the form of an electronic control system. One version, as illustrated in Figs. 1 and 2, was designed to provide for control of tank pumps through valve limit switches installed on motor-operated suction valves.

Control units (Fig. 1), placed at loading racks or other control points, are connected in groups of six to controlled units (Fig. 2) situated near the tank pump motor and associated valve switch gear, by a single RG-8U coaxial cable.

A key in the control unit (Fig. 1), switched to the "on" position causes a signal of fixed frequency to be transmitted over the common coaxial cable to all controlled units in the group. This signal is received by the station tuned to that frequency. The signal is amplified and rectified to operate a relay in the controlled unit circuit. The contacts of this relay become the closing medium for the valve motor starting equipment. The valve motor limit switch in turn operates the tank pump motor starting equipment.

When closed, an auxiliary contact on the motor starter causes a signal of another frequency to be transmitted from the controlled unit over the same coaxial cable to the control unit. The receiver of the control unit at the control station tuned to this frequency receives the signal and a lamp is lighted to indicate that the motor starter has closed.

Where a more positive indication of an energized motor is desired, a pressure switch on the pump discharge can be used in place of the motor starter auxiliary contacts.

A seventh frequency pair is allocated to the spare control and controlled units that can be easily substituted in the event of either control or controlled unit failure.

Although only seven frequency pairs are currently used per group, it has been demonstrated that as many as 16 pieces of equipment could be controlled in the range of 10 to 22.4 kilocycles over one coaxial cable. A maximum of six tank pumps per cable was established so that continued operation of the remainder of the tank farm could be maintained in the case of damage to one of the cables.

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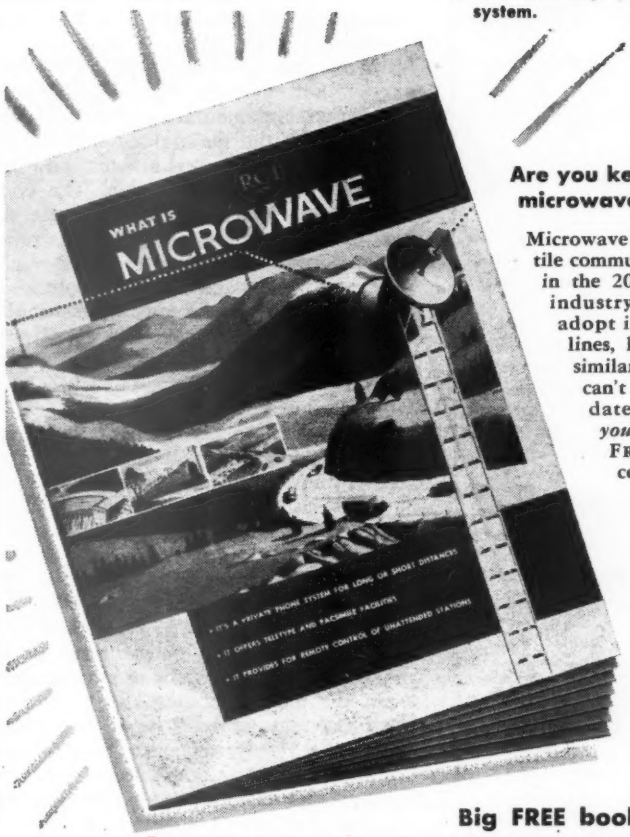

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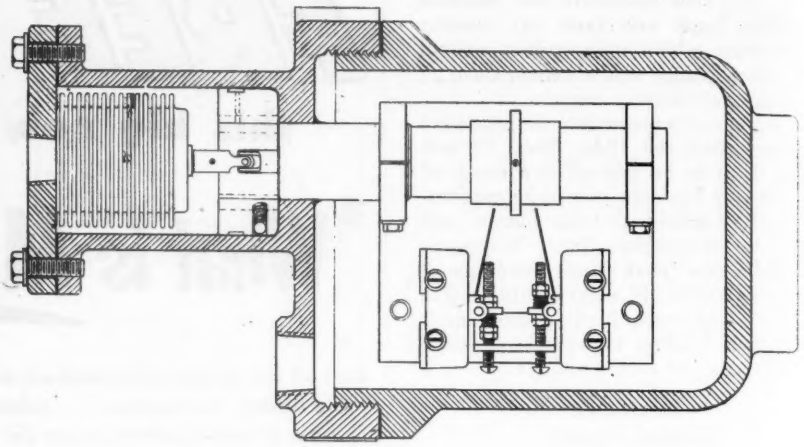


FIG. 3. Flow demand controller switch.

The direct buried coaxial cables operate on a maximum potential of only one-half volt.

A fail-safe control would not be too essential for tank loading pumps. For control of receiving line valves, however, it is essential that failure of the control system not close the valve. For fail-safe operation, a momentary key may be substituted for the maintained key in the control unit to impress a short duration signal on the coaxial cable. The controlled unit relay will then operate an impulse relay in the motor starter equipment. Operation of the above key will alternately start and stop the motor.

Signal lamps in the control unit would thus normally burn continuously. Upon fulfillment of the function, the circuit is so designed to continuously flash the control unit red lamp.

The system was first installed and tested during the modernization of the Des Moines terminal tankage. Subsequent installations were made at all new company tank installations and at most originating tank farms.

Flow Demand Controller

A characteristic terminal problem is the great variation in loading rates. Peak period rates may be 75 per cent greater than the daily average. The peak day loadings may, in turn be 50 per cent above the yearly average. The demand for individual products may vary to an even greater extent from peak to off-peak seasons. A similar problem exists in pipe line operation, as previously noted, when an originating tank may be required to supply rates from 14,000 to 90,000 bbl a day.

The impracticability of installing single large tank pumps at all tanks to meet maximum peak demands is obvious. The idea of placing large pumps at a selected few tanks is also unsound because of seasonal product demand and lack of equipment standardization or flexibility. A more practical solution is the installation of multiple parallel units of smaller size. As loading demands increase, one or more extra pumps may be called into service. The very nature of terminal loading prevents prediction of flow demands. There may be lengthy periods when loading of the peak product is at a virtual standstill. The required operation of the second and possibly a third parallel pump might only be a small fraction of the time.

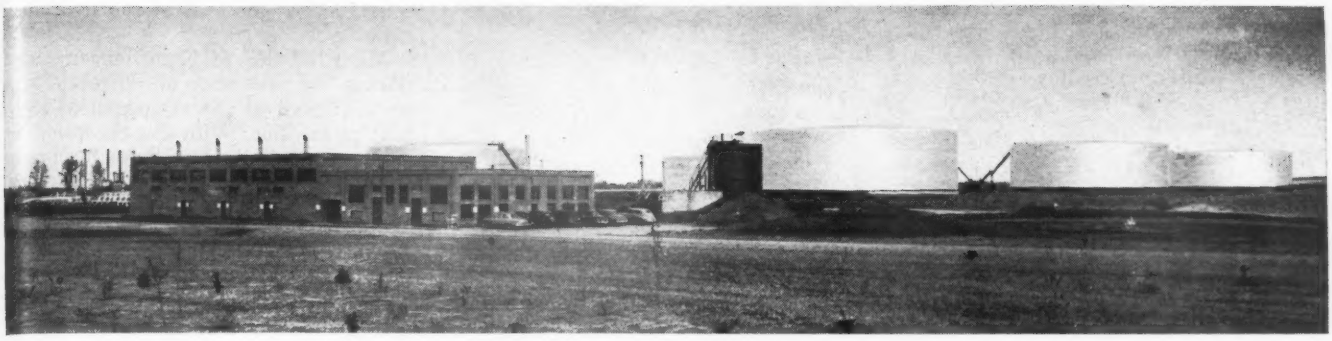
A simple means of automatically calling the standby pumps into operation was desired. For this purpose, the flow demand controller or switch was devised. Fig. 3 is a cross-sectional view of the bellows operated switch mechanism.

The highly responsive bellows is actuated by the small differential pressure of a supply line orifice. The higher upstream pressure is admitted through the end plate connection into the bellows and the lower pressure to the cavity around the bellows.

The linkage rod positions and Alnico-5 permanent cylindrical magnet inside the sealed stainless steel tube. The companion Alnico-5 magnet concentrically surrounding the tube matches position with the inside magnet. The first single pole, double throw microswitch opens to start the first standby pump when the flow demand is such that a single pump cannot supply sufficient pressure to maintain maximum spot loading rates. The second switch closes to start the second standby pump. The adjusting screws, together with the proper choice of orifice plates, gives a wide range of flow control settings.

A 30-sec time delay switch in the shutdown circuit maintains pump operation during a short period of decreased demand while loading lines are being adjusted between compartment loadings.

This controller holds power consumption to a minimum for various supply rates and in doing so also maintains the highest possible load power factor. Any flow rate up to the maximum output of the parallel pumps is automatically available. The permitted use of standard pumping units in combination affords greater flexibility and dependability and at the same time simplifies the maintenance and spare pump problem. * * *



General view of Edmonton pump station showing a portion of the six 140,000-bbl storage tanks.

Pipe Line Operating Problems in Canada

Interprovincial has encountered certain difficulties, which have called for individual treatments to solve

F. J. STUBBS

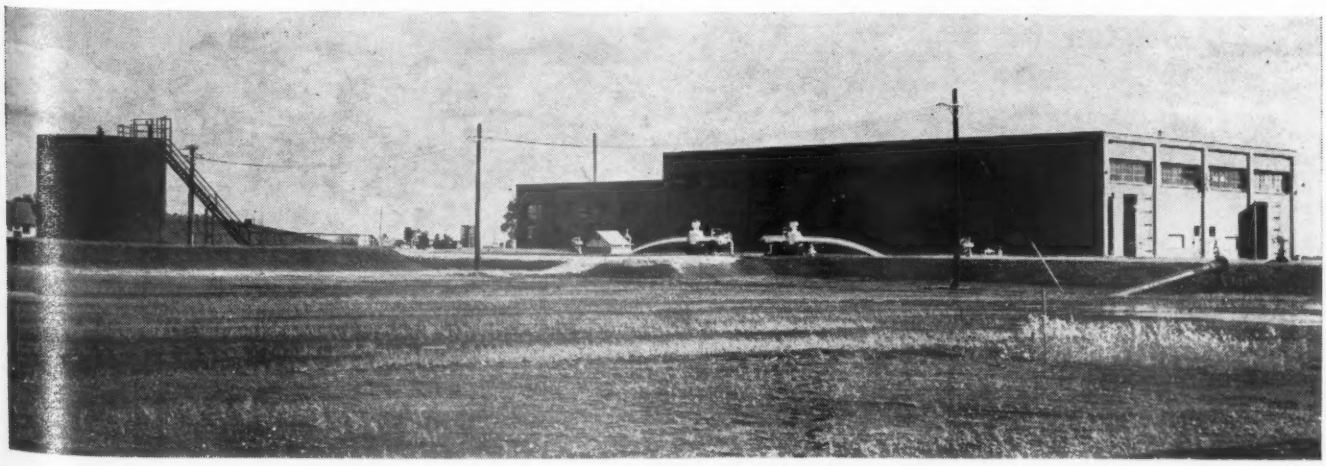
SUCCESSFUL exploration and development drilling that followed the Leduc discovery in February, 1947, pushed Western Canadian proved oil reserves to something in excess of one billion barrels, with more than 1800 wells capable of producing by the fall of 1950. This potential put Canada in a position to produce about one-half of her crude oil requirements, and the population distribution and vastness of the country itself, were factors that made Interprovincial Pipe Line a necessity.

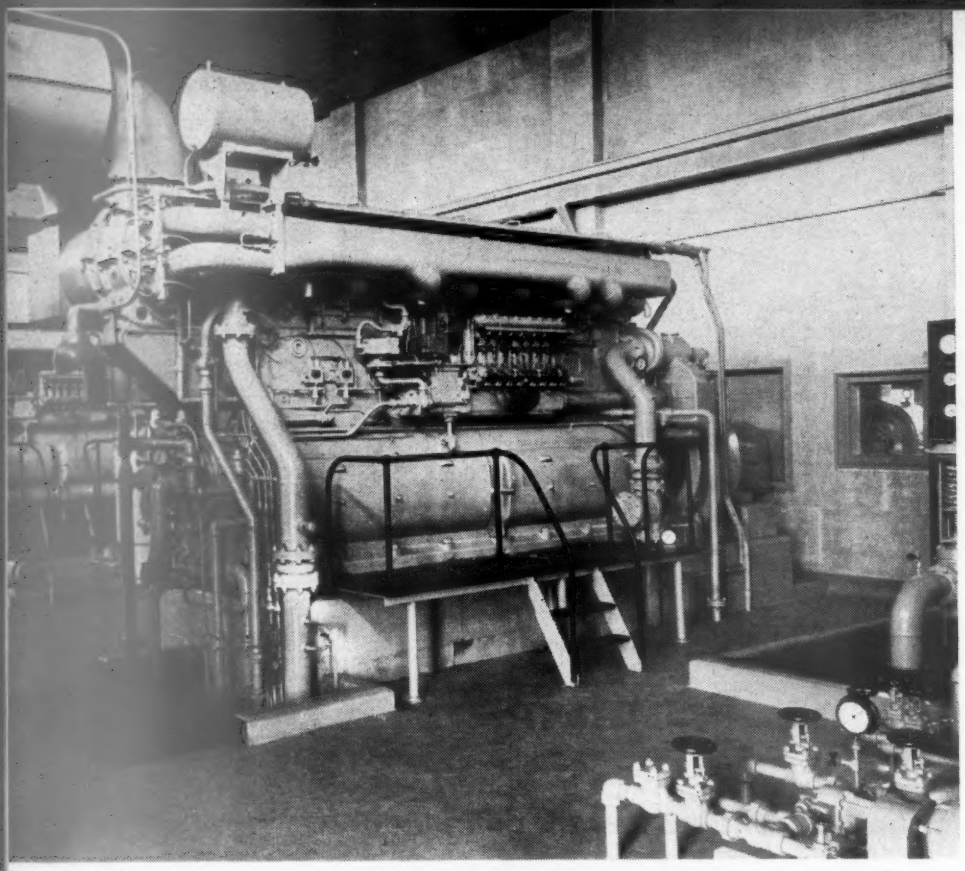
The start of Interprovincial's system is Edmonton, Alberta, and the location of its initial main line pumping station and a tank farm with a storage capacity of 900,000 bbl. Redwater crude is delivered to this tank farm by the company's 30-mile 16-in. OD pipe line from Redwater, Alberta, while the Leduc type crude is gathered and transported to the company tankage by other pipe line companies. The Edmonton station, taking suction from this tank farm, pumps the oil through 20-in. OD pipe to Regina, Saskatchewan. The line from Regina to Gretna, Manitoba, is 16-in. OD and the rest of the line to Superior, Wisconsin, is 18-in OD. This arrangement of pipe sizes was necessitated due to a firm commitment having been made with a Canadian manufacturer for 16-in. OD when the line was planned to run only as far east as Regina, and the fact that because of the low operating pres-

The Author

Frederick John Stubbs, assistant general manager of Interprovincial Pipe Line Company, was born in Galt, Ontario. He took his formal education at the University of Toronto where he graduated in mechanical engineering in 1933. Upon graduation he joined the engineering department of Imperial Oil Limited at Sarnia. In 1948 he was appointed technical adviser to the president of Transit and Storage Company at Wayne, Michigan, and in 1949 was appointed vice president and general manager. In 1950 he transferred to Interprovincial Pipe Line Company as assistant to the executive vice president and in the same year was made assistant general manager.

An overall view of the pump station at Gretna, Manitoba. At extreme left is one of five employee houses.





An 8-cylinder turbo-charged diesel engine at Edmonton pump station.

sures required on the American section of the line it was economically sound to use a large diameter pipe and consequently require fewer stations.

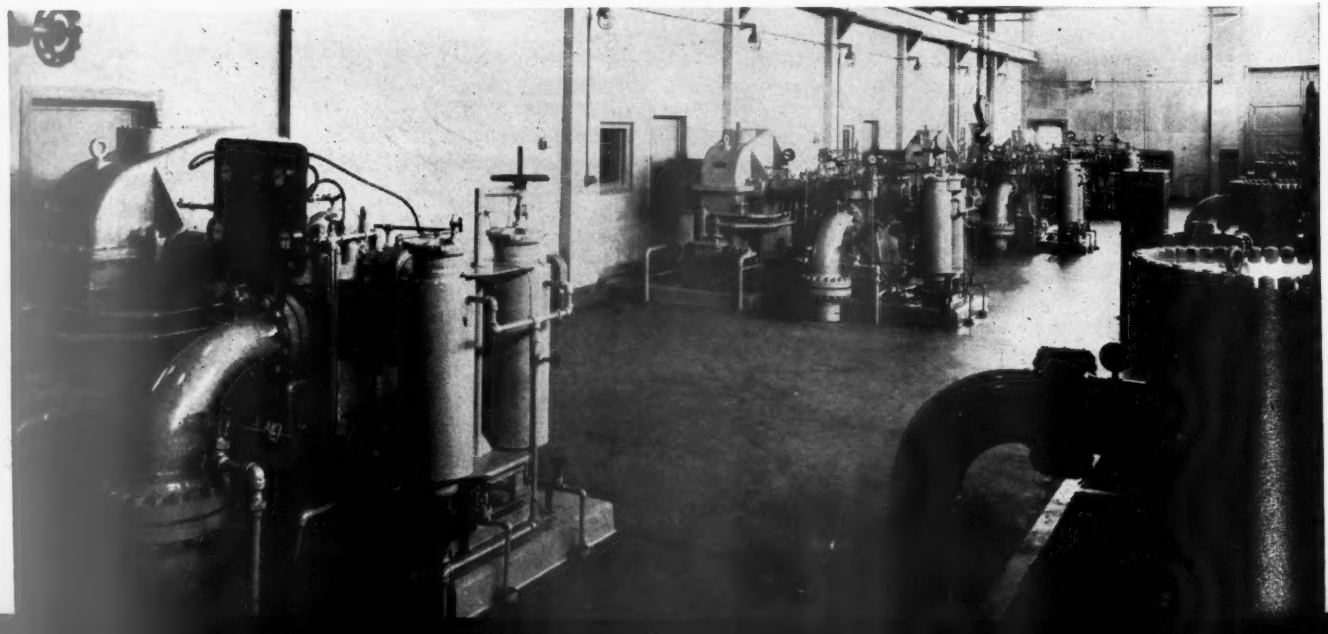
The system has basically two main outlets: (1) Prairie refineries along its route and (2) the Superior terminal. As all of these outlets may require either Redwater or Leduc crude, the system is so designed, by means of breakout tankage at Regina and Gretna, that it is possible to batch the oil and deliver to any point a specific type of crude without affecting the flow of the main stream. The problem of operating the line to maximum capacity can accordingly be seen to be dependent not only on the various sizes of pipe involved but also on the crude requirements of the shippers and the fact that the Superior terminal has an open navigation season of about 230 days.

Early in 1951, with six pumping stations on the line and twelve 150,000-bbl tanks available at Superior, capacity tests were run on the entire line. The initial design figures of 95,000 bbl a day out of Edmonton, with 53,000 bbl a day into Superior, were found to be conservative. In actuality, at the season's peak, the system was pumping 105,000 bbl a day out of Edmonton, 74,000 bbl out of Regina, and Superior was receiving 64,000 bbl. For the year 1951, out of a potential capacity of 34,283,537,489 bbl-miles with no limitations due to the short navigation season, the actual throughput was 24,314,926,000 bbl-miles, or 72 per cent of the hydraulic capacity.

Many of the problems encountered during the first year of operation can be attributed to the geographical location of the line. With the exception of Edmonton and Regina where the pump stations are adjacent to large centers, all stations and delivery facilities are at or near small villages in a country noted for its long, cold winters. At these centers, the company has virtually built self-contained communities, complete with all utilities except electric power, which is purchased from utility companies. This has resulted in precautions having been taken to assure a continuous supply of water with all lines deeply buried, as frost can be expected to a depth of 6 to 7 ft below the surface. At two of the stations both a rotary snow plow and a snowmobile proved a requisite and even then there have been occasions when it has been impossible to maintain transportation between these stations and the nearest communities.

The system's main stream is made up of Redwater and Leduc crudes, neither of which has presented any major problems. It is interesting to note here that the minimum oil temperature during the year 1951 was approximately 25 F in the months of February and March, while the maximum temperature of 60 F was reached in August. These temperatures occurred in the line, which is buried throughout its entire length with a minimum cover of 3 ft. The Redwater crude, particularly, has a relatively high wax content and at the peak of the summer operations, scrapers, after a run of 220 miles, have brought in a ton of wax ahead of them. This wax, at first, had a particularly damaging effect on the mechanical seals with which the centrifugal pumps are equipped, as they were cooled by crude oil taken from the discharge side of the individual pumps through cellulose filters. This wax plugged control valves and filters, causing numerous seal failures. This problem has been solved by taking the seal oil from a dead section of the line on the discharge side of the station and de-

Pump room at Edmonton station; at right can be seen the high pressure crude-to-engine jacket water exchangers.



livering it through a common header to each pump.

The engines, with exception of Edmonton that are dual fuel, have all run satisfactorily on the crude transported, although limited experience has shown the Redwater type of crude to be less troublesome fuel than Leduc, primarily due to the gumming characteristics of the latter.

Initially, the entire pipe line was protected against external corrosion by the application of a protective coating of coal tar enamel, glass wrap, and coal tar impregnated asbestos felt. Cathodic protection was considered in the original design and as the first step in this program a survey was made of the soil conditions along the entire line in the summer of 1951. This survey showed all the original coating to be in excellent condition, and the nature of the ground such that with a few minor exceptions the imposed current in the ground at the stations with the installation of cathodic rectifiers and ground beds would be sufficient to protect the entire line. All station lines are isolated from the main line by insulating gaskets.

Tankage at Superior will be protected by cathodic rectifiers and ground beds but it is anticipated that, due to the nature of the soil, it will be more economical to protect the Edmonton tanks with magnesium anodes. Similar consideration for the lines on the loading dock at Superior may be the best solution. When the cathodic protection equipment has been installed this summer a complete resurvey of the line is planned.

At this time it is difficult to estimate the internal tank corrosion rates that will be encountered, but from present indications, it appears that the corrosion rate diminishes in a westward direction as a result of the lower relative humidity. On this premise, only the tank bottoms at Superior were internally coated with coal tar enamel reinforced with glass fiber and on all tanks vapor space corrosion is mitigated by ammonia injection.

The Superior terminal was designed for efficient operation with a minimum of personnel providing rapid handling of the tankers. Interprovincial's responsibility ends at the loading dock and is in no way connected with the lake transportation, although it must always have oil available for loading.

The terminal facilities provide for the handling and disposal of ballast water in volumes from 15,000 to 50,000 bbl per ship and a loading rate of 20,000 bbl an hour through two 24-in. lines from the tank farm to the dock. For the period April 21 to December 1, 1951, 13,700,000 bbl were loaded through these facilities with an average loading time of approximately 6½ hr for one of the big tankers. Last season, the two largest fresh water tankers in the world, *Imperial Leduc* and *Imperial Redwater*, were used exclusively on this run and they lifted a total of 11,000,000 bbl, making the round trip between Sarnia, Ontario, and Superior in approximately five days.

Aerial photograph of dock at Superior; in the background original twelve 150,000-bbl tanks at terminal. At present 12 additional 217,000-bbl tanks are nearing completion and 12 more will be erected during summer of 1952, making a total of 36 tanks.

Crude oil requirements both on the prairies and in the east continue to increase and as a result a continued expansion program is under development by Interprovincial. In 1951 five stations were added to the system and one more is to be added this year. One hundred miles of 16-in. line between Regina and Gretna is to be looped and storage capacity is being increased at Superior to give a total of 7,000,000 bbl. This expansion will permit the system in 1953 to handle out of Edmonton 155,000 bbl a day, with summer deliveries into Superior of approximately 100,000 bbl a day. For 1952 it is contemplated that some 20,000,000 bbl will be lifted during the navigation season. * * *

A more detailed aerial view of dock at Superior showing a 115,000-bbl Redwater class of tanker. Left is the tankage comprising the ballast water treating plant.

NEWS

Final Portion of Ohio's New Pipe Line Operating

The first crude oil through the final portion of The Ohio Oil Company's new 355-mile pipe line between Wood River, Illinois, and Lima, Ohio, has arrived at Lima, it was announced by O. F. Moore, manager of the company's pipe line department.

The completion of the last 117-mile section of the line from Sheridan, Indiana, to Lima marks the final stage of the company's project of replacing and increasing the capacity of its former crude oil trunk pipe line system, which had been operating for more than 40 years. Work was begun on the new line in September, 1950, and the portion between Wood River and Sheridan has been in operation since last June.

The new 20 and 22-in. line is available to receive shipments at Wood River from all major lines that transport crude to the St. Louis area from the west, southwest, and Rocky Mountain area, Moore said. At Patoka, Illinois, it can receive shipments from or make deliveries to other lines that junction in that area. Other delivery points are St. Elmo, Illinois; Indianapolis, and Lima.

At Lima, it connects with other pipe lines for transportation to points in Ohio, Michigan, Pennsylvania, New York, West Virginia, and Canada. Oil may also continue eastward from Lima through Ohio Oil's line to the Ohio-Pennsylvania border, where connecting lines transport it to the east coast.

Service Pipe Line Tank Cleaning Program

Eighty-four tanks in Kansas, Missouri, Illinois, Oklahoma, and Texas have been cleaned since 1949 in the tank cleaning program of Service Pipe Line Company, according to R. M. Carter, tank superintendent. A total of 407,844 bbl of merchantable oil was reclaimed from 644,151 bbl of settlings in the tanks, representing an average recovery of 63 per cent.

Carter said the purpose of the extensive clean-up job was three-fold: (1) To prepare tanks for repairs and improvements, (2) to remove the inflammable contents from those tanks to be left idle or dismantled, and (3) to restore working space occupied by the bottom settlings.

The Natasco Company of Tulsa cleaned 57 tanks in Kansas, Missouri, and Illinois, and nine in Oklahoma; the Safety Tank Cleaning Company of Gladewater, Texas, cleaned 17 in West Texas and Kansas, and the Reagin Trucking Company of Cushing, Oklahoma, cleaned one tank in Kansas.

Most of the tanks were returned to service. They ranged in size from 2500 to 80,000 bbl capacity. Carter said a number of other tanks were cleaned by Service Pipe Line crews during this same period but were not made a part of the report.

Gas Storage Plant Gets Final Approval

The decision filed by a Federal Power Commission presiding examiner authorizing Washington Gas Light Company, of Washington, D. C., to construct and operate a standby gas storage plant near Rockville, Maryland, has become effective as the final decision and order of the commission.

The decision, filed by Examiner Samuel W. Jensch, was issued on February 21. As no exceptions were filed and the commission did not initiate its own review, the decision has become effective in conformity with the FPC's Rules of Practice and Procedure.

The decision is conditioned to require the company to use the standby facilities whenever they can be useful, including peak shaving to reduce the cost of gas purchased from Atlantic Seaboard Corporation, its supplier. Washington had proposed to use the plant as a standby facility to provide gas only if a break occurred in the pipe line of the supplier.

The commission last August 9 granted temporary authorization for the company to begin construction of the plant, subject to the condition that if necessary the facilities be used for peak shaving to reduce the cost of gas purchased from Seaboard.

The plant, estimated to cost approximately $6,820,000, includes underground steel pipes with a storage capacity of 70,000,000 cu ft of natural gas, and propane liquid facilities having a storage capacity of 625,000 gal of propane, which, when gasified, will have a daily capacity of 30,000,000 cu ft of natural gas equivalent. Total delivery capacity of the plant is 7,000,000 cu ft of gas per hr, for a 14 or 15-hr period.

Flexible Pipe Cleaning Company New Firm Name

The pipe cleaning division of the Flexible Sewer Rod Equipment Company has changed its name to The Flexible Pipe Cleaning Company, according to a recent announcement by William Osborn, founder. George Ellis, well known pipe reconditioning engineer, is now general manager of the company. Lee Gardner, formerly in the West Coast office has been transferred to the Mid-Continent area with headquarters in Dallas, Texas, in the Republic National Life Building.

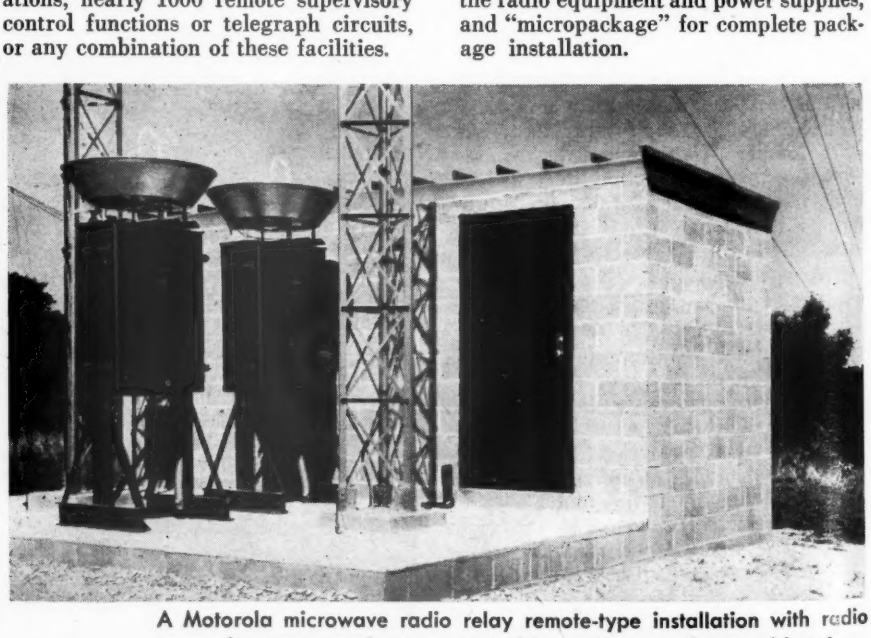
Motorola 24-Channel Microwave Relay Systems

Motorola has announced the introduction of a new line of multiplexing equipment for its industrial microwave radio relay system that provides facilities for up to 24 voice channels. To date, Motorola has installed more than 20 systems of microwave radio relay equipment with up to 12 channels. Experience from these, which includes two complete 1000-mile networks, shows a need exists for more powerful facilities.

A cross-country communications system utilizing this advanced design multiplex equipment is capable of handling either 24 normal voice circuits, more than 400 teletype or telemetering operations, nearly 1000 remote supervisory control functions or telegraph circuits, or any combination of these facilities.

Introduction of this new multiplex equipment permits the users of previously supplied Motorola microwave 10- or 12-channel systems to expand them up to 24 channels when desired. The new equipment, featuring double frequency modulation (FM) sub-carrier type multiplexing, incorporates the same principles as 10- and 12-channel systems previously supplied, and operates in the 6575-6875 megacycle frequency band.

Motorola microwave equipment is available in two basic designs, remote type installation for use where the customer already has housing facilities for the radio equipment and power supplies, and "micropackage" for complete package installation.



A Motorola microwave radio relay remote-type installation with radio frequency equipment mounted in outdoor weatherproof housings.

AGA to Consider Gas Industry Future

"Where Do We Go From Here?" might be called the theme song of the Spring Conference of the Natural Gas Department of the American Gas Association to be held at the Biltmore Hotel, Los Angeles, California, May 12 and 13. According to the preliminary program future plans and prospects will occupy most of the two-day conference.

Charles E. Bennett, chairman, Natural Gas Department, AGA, and president, The Manufacturers Light and Heat Company, Pittsburgh, Pennsylvania, will preside at general sessions both mornings. He also will deliver the keynote address, highlighting the spectacular advances made by the natural gas industry and pinpointing their significance.

Bennett was just recently elected president of the Association by the Executive Board to succeed the late George F. Mitchell, former president of The Peoples Gas Light and Coke Company, Chicago, Illinois, who died March 26, 1952, while serving as president of AGA. At the same time, Frank C. Smith, president, Houston Natural Gas Corporation, Houston, Texas, was elected vice president of AGA.

Bennett was graduated from the University of Wisconsin with a BS degree in mechanical engineering. He began his business career as a fire prevention engineer for the state of Wisconsin. He entered the public utility field as superintendent of gas plant for the Madison (Wisconsin) Gas and Electric Company in September, 1915.

Frank C. Smith has been president of the Houston Natural Gas Corporation since 1933 and has been nationally prominent in the gas industry for many years. He has served continuously from 1946 as a director on AGA executive board, and last year was chairman of the General Promotional Planning Committee.

Most observers agree that the nation's great natural gas system has just begun to expand. Many new markets are opening and existing markets are increasing constantly. The natural gas industry has allocated some $3 billion for new plant and facilities in the next four years.

Claude A. Williams, president, Transcontinental Gas Pipe Line Corporation, Houston, is particularly qualified to forecast: "What's Ahead for the Natural Gas Industry?".

Availability of steel and other vital materials will determine the immediate future of the industry's proposed construction program. Alden G. Roach, president, Columbia-Geneva Steel Division, United States Steel Company, San Francisco, will bring the conference an outside viewpoint on priorities in his discussion: "Steel for the Pipe of Plenty."

Other factors having direct bearing on the future of the natural gas industry are tentatively listed for general sessions programs. Dual regulation will be discussed by a prominent state utility commissioner. More and more attention is being given to natural gas research projects under the AGA Promotion, Advertising and Research (PAR) Plan. A report and an analysis of natural gas research work will be presented at the meeting. B. K. Dunshee, Pacific Gas and Electric Company, San Francisco, and H. I. Putnam, Texas Eastern Transmission Corporation, Shreveport, will present a paper on "Problems of Right-of-Way Acquisition and Usage."

The afternoon sessions will be devoted to meetings sponsored by the transmission and underground storage committees, with Joe T. Innis, Northern Natural Gas Company, Omaha, and Fenton H. Finn, New York State Natural Gas Company, Pittsburgh, as co-chairmen.

John Riegle, Jr., Southern California Gas Company, Los Angeles, will present a paper on: "Storage of Gas in a Partially Depleted Oil Zone." Field experiences with steam compressors will be the topic of a discussion. A report will be given on the large diameter meter tube research and testing program being conducted by AGA and ASME by Ernest E. Stovall, Lone Star Gas Company, Dallas. The place of gas turbines in gas pipe line pumping will be pictured by J. O. Stephens, Westinghouse Electric Corporation, South Philadelphia.

A forum on pipe line safety will present a discussion on the new ASA Code for Pressure Piping, directed by Frank S. G. Williams, Taylor Forge and Pipe Works, New York, New York. A report on the new specifications for field welding and radiographic testing of pipe lines will be given by Robert G. Strong, Natural Gas Pipeline Company of America. Williams and Strong head sectional committees concerned with subjects covered by their respective reports.

Underground storage of natural gas is a subject of utmost importance today. Raymond W. Todd, Pacific Lighting Company, will describe the operations of LaGoleta storage field, one of the largest in the country. In Chicago, the gas utility and pipe line companies, are working on a plan to store natural gas in Herscher Dome, a natural rock formation that never held gas or oil. M. V. Burlingame, Natural Gas Pipeline Company of America, will describe this natural reservoir and its potentialities. John V. Goodman, Equitable Gas Company, Pittsburgh, will offer some interesting storage operating statistics.

Dr. Gilson H. Rohrback, California Research Corporation, Los Angeles, will speak on "Condensate Well Corrosion" at one of the afternoon sessions. C. H. Zachary, president, Southern Union Gas Company, Dallas, will act as moderator at a panel discussion on pipe line operations. Members of the panel will be Grove Lawrence, Southern California Gas Company, and John E. Overbeck, Columbia Gas System Service Company, Columbus, Ohio. Several committee meetings are scheduled.

Pipe Line Expansion Shown in DPA Grants

Defense Production Administration has granted certificates for accelerated tax amortization to pipe line companies totaling millions of dollars. DPA offers fast tax write-off allowances to companies as a means of encouraging them to expand their facilities to produce defense and defense-supporting goods and services. The largest certificate issued, including all industries, went to Trunkline Gas Company of Houston, Texas. DPA gave the company a certificate authorizing it fast amortization on 25 per cent of $79,498,457.

Other pipe line companies included: Plantation Pipe Line Company, Atlanta Georgia, 25 per cent of $51,640,000. Panhandle Eastern Pipe Line Company, Kansas City, two certificates on 25 per cent of a total of $42,158,429. West Texas-Gulf Pipe Line Company, Pittsburgh, 25 per cent of $39,652,250. Shell Pipe Line Corporation, Houston, 25 per cent of $35,594,500.

The Texas Company, Cathy, Maryland, 40 per cent on $350,800. Southern Natural Gas Company, Birmingham, 25 per cent on $7,917,700. The Texas Company, Spartanburg, South Carolina, 40 per cent on $355,705. The Texas Company, Doraville, Georgia, 40 per cent on $480,000; at Columbus, Georgia, 40 per cent on $244,806, and at Birmingham 40 per cent on $345,661.

Ashland Oil and Refining Company, Lexington, Kentucky, 40 per cent on $187,000, and 25 per cent on $1,272,950. Standard Oil Company (Ohio), Toledo, 40 per cent on $238,300 and 25 per cent on $705,400.

Continental Pipe Line Company, Ponca City, Oklahoma, 25 per cent on $4,180,000. Pan American Pipe Line Company, near Arden, Texas, 25 per cent on $4,089,000. Phillips Petroleum Company, Bartlesville, Oklahoma, 40 per cent on $405,933, and 25 per cent on $4,601,217. The Texas Pipe Line Company, Houston, 15 per cent on $1,543,715.

Phillips Pipe Line Company, 25 per cent on $17,724,902. Tide Water Pipe Line Company, Haskell County, Texas, 25 per cent on $94,280. Triangle Pipe Line Company, Corpus Christi, Texas. 25 per cent on $5,807,805.

Warren Petroleum Corporation, Norsworthy, Texas, 25 per cent on $355,000. Phillips Pipe Line Company, Sweeny, Texas, 25 per cent of $856,228, and at Bartlesville, 25 per cent on $1,007,218. Texas Pipe Line Company, 25 per cent on $3,516,948. Consolidated Gas Utilities Corporation, Oklahoma City, 45 per cent on $488,976.

Phillips Pipe Line Company, Bartlesville, 25 per cent on $114,585. Union Carbide and Carbon Corporation, Galveston, Texas, 25 per cent on $1,526,000. Salt Lake Pipe Line Company, Salt Lake City, 25 per cent on $229,000. Pacific Gas and Electric Company, Ignacio, California, 25 per cent on $29,352, and 50 per cent on $258,687 at Sacramento City, California.

Platte Pipe Line Is About Half Completed

A third construction crew has begun work on the Platte Pipe Line Company system, the 20-in. pipe line that will carry crude oil from Wyoming, Colorado, and Nebraska to Wood River, Illinois.

The new crew has been placed on the job by contractors R. H. Fulton and J. T. Brodie who have the contract for the section of the line between Holdrege, Nebraska, and the Nebraska-Kansas state line. The crew is beginning its work at the state line and is working westward toward Holdrege.

Two other construction crews, which started working last year, have been active throughout the winter and have completed 500 miles of the 1056-mile pipe line. O. R. Burden Construction Corporation has completed the segment between Salisbury, Missouri, and Wood River, Illinois, and is now working westward from Salisbury toward the Missouri River crossing south of St. Joseph, Missouri.

R. H. Fulton and Company has completed all the pipe line laying in Wyoming and is now working eastward from the Wyoming-Nebraska state line.

The Platte Pipe Line Company is scheduled to receive the final 175 miles of pipe during May, June, and July.

The line will have main pump stations at Casper, Wyoming; Ogallala, Nebraska; Marysville, Kansas, and Salisbury, Missouri. Injection stations will be at Chatham, Lost Cabin and Guernsey, Wyoming, and at Gurley, Nebraska. With these stations, the capacity of the pipe line will be 110,000 bbl a day. As production in Wyoming, Nebraska and Colorado increases, the capacity of the line can be increased by adding additional pump stations at Yoder, Wyoming; Holdrege, Nebraska, and at Gower and Monte, Missouri.

The completion of the Platte line will provide a market outlet for approximately 100,000 bbl of crude oil a day, which at this time is shut in for lack of a market. The cost of this project, which is so important to the oil industry and the area that it will serve, will be $60,000,000. The Platte Pipe Line Company is owned, either directly or through subsidiaries, by British American Oil Company, Ltd., Continental Oil Company, The Pure Oil Company, The Ohio Oil Company, and Sinclair Oil.

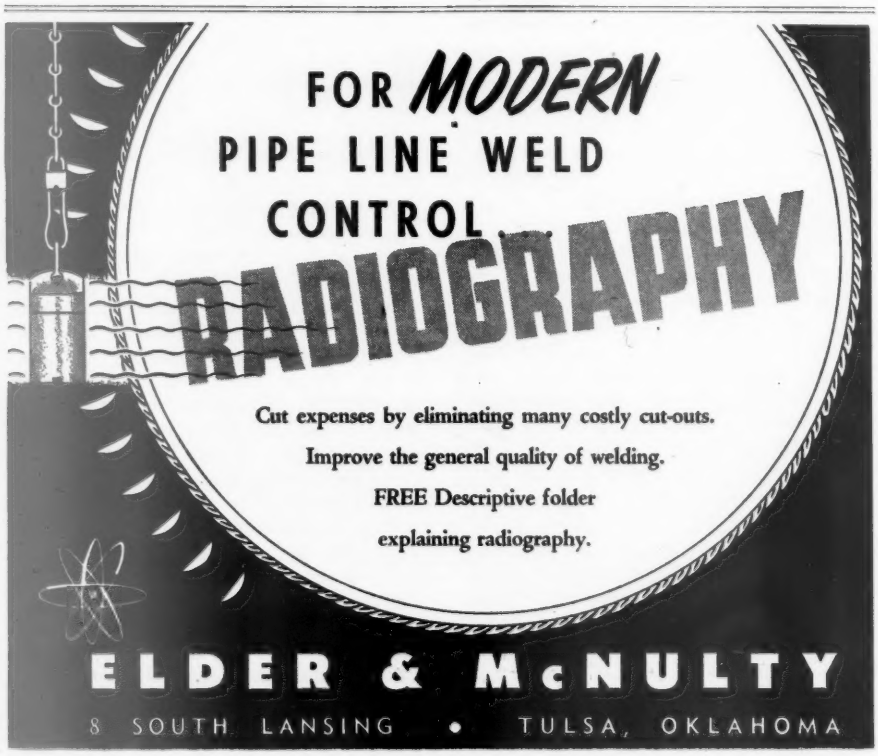
Interstate Wins National Safety Council Award

First place for the best safety record in Group A, Oil and Gas Pipe Lines, in the National Safety Council's petroleum safety contest has been awarded to Interstate Oil Pipe Line Company, according to Ned H. Dearborn, council president.

Dearborn notified Interstate officials that the company's lost time industrial accident frequency rate was the lowest of the 23 major oil and gas pipe line companies competing in Group A for the year 1951. Interstate's winning frequency was 1.63 lost time accidents per million man-hours worked, as compared with the entire group average of 8.52.

Interstate's actual record was four lost time injuries during 1951, with a total of 2,446,563 man-hours worked by an average of 1286 employees during the contest period

Composing Group A, Oil and Gas Pipe Lines, in the contest were the 23 major pipe line companies of the nation having the highest number of man-hours worked during the contest period. Crude oil, natural gas, and products pipe line companies are included in the group.



Petrol Caltex Completes Oil Line in Italy

Petrol Caltex Oil Company has completed a 93-mile crude oil pipe line from Savona, Italy, to its refinery at Trecate over terrain that at times was so rough the 40-ft joints of pipe had to be carried into the right-of-way on the shoulders of Italian workmen. The line, which cost $5,000,000 to build, will have an annual capacity of 900,000 tons of crude oil with one pumping station. A second station, contemplated for the future, will increase the capacity to 1,200,000 tons.

At the Savona end of the line a submarine line is to be laid to facilitate the unloading of tankers. This will be done because of the difficulty of dredging the rocky bottomed Bay of Vado Ligure, where Petrol Caltex has its seaside station.

Midwestern Introduces Pipe Wrapping Material

The Midwestern Engine and Equipment Company, Inc., of Tulsa, Oklahoma, nation-wide distributors of pipe wrapping materials, have recently introduced "Protecto Wrap", a new and unique glass-base pipe hand-wrapping material that eliminates carrying hot dope from one wrapping job to the next. The wrap is easily applied by "flashing" with a low temperature torch thereby melting the enamel contained within the material itself. Protecto Wrap can then be easily wound around the joint, fitting, coupling or "hot spot", providing an even, corrosion-resistive coating.

The new wrap is a protective coating of plasticized coal tar enamel prefabricated with a woven glass fabric that acts as carrier and reinforcement for the paint. Supplied in widths from 2 in. to 24 in. Protecto Wrap is interwound with a paper separator that insures even distribution of the coating as well as easy unwinding regardless of temperature. The wrap has been designed to give the standard 3/32-in. coating when 50 per cent overlap is used.

Midwestern officials point out that extensive field usage has shown Protecto Wrap's greatest advantage to be its all-glass base. The glass, being completely inorganic, will not "wick out" the protective fractions of the coating nor will exposed strands carry outside moisture into the wrap. This feature, Midwestern asserts, virtually eliminates "holidays".

The Midwestern Engine and Equipment Company is making Protecto Wrap available as a "complete package", if desired. This package includes Protecto Wrap and torch assembly application equipment. Midwestern is the exclusive pipe line distributor for Owens-Corning Coromat underground pipe wrap; Kapco Rock Shield for pipe; Glasfab membrane fabric hand-wrap, and Owens-Corning outer wrap.

☆ ☆ ☆

Sixty million tons of steel, enough to encircle the globe fifteen times, is now buried in the soil of the United States to serve the gas and oil needs of the country.

New Microwave Wiring Method Described

A revolutionary method of microwave wiring that will not only result in huge savings in production costs but will greatly reduce the need for critical materials and highly skilled manpower was described before the second session of the national convention of the Institute of Radio Engineers held at the Grand Central Palace, New York City.

Details of the new technique, which is designed to replace the bulky, expensive waveguide circuits or "plumbing" were outlined for the first time in a series of three papers presented by engineers of Federal Telecommunication Laboratories, Inc., Nutley, New Jersey, research associate of the International Telephone and Telegraph Corporation.

This new advance in the electronic art is based on the use of a ground plane system that acts as a radio mirror for a conductor supported above it, creating in effect, a parallel wire system in which perfect symmetry is obtained without elaborate machining or other processes.

Chief advantage of the new technique is that it is many times cheaper than the current method of producing microwave circuits, it was stated.

Under the techniques perfected by FTL engineers, the new wiring can be produced directly from diagrams simply by etching the circuits on a dielectrically coated base plate or by the employment of stamping and embossing techniques. The resulting equipment is not only several hundred times lighter, but a great deal more compact than existing types of microwave plumbing. The magic "T" waveguide weighs about 15 lb compared with a few ounces under the new method.

The papers, presented at the IRE convention were: "Microwave Wiring" by D. D. Grieg and H. Engelmann; "Simplified Theory of TEM Propagation Along Conductor Ground-Plane Transmission Systems" by F. Assadourian and E. Rimai, and "Microwave Components for Conductor Ground Plane Transmission Systems" by J. A. Kostriza.

M. E. Grant Elected Vice President Plantation

The election of M. E. Grant as executive vice president of Plantation Pipe Line Company has been announced by C. R. Younts, president. Grant takes over his new duties July 1.

Grant comes to Plantation from the Shell Oil Company, New York. He has been closely connected with pipe line work on development, scheduling, and financial sides during his numerous assignments with that company.

Grant has been with the Shell organization since 1930. His career included assignments in public relations, legal, and as an executive assistant to Shell's vice president in charge of transportation and supplies. He is presently a director of Inland Pipe Line Corporation.

He received his degree in law from the University of Missouri.

Interstate Lets Contract for Line Replacement

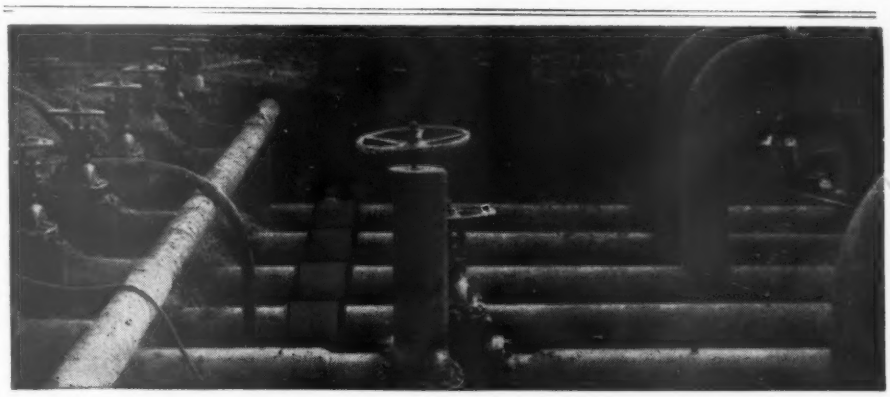
Interstate Oil Pipe Line Company officials have announced in Shreveport, Louisiana, the letting of a contract to Latex Construction Company of Georgia for the construction of 32 miles of 20-in. crude oil pipe line between Bunkie and Melville, Louisiana, pumping stations.

The new line is to replace multiple 8-in. and double 12-in. lines now in service on this section of Interstate's Shreveport-Baton Rouge trunk line. It is the third project to be started under the company's previously announced expansion and modernization plans, which will involve the expenditure of about $30,000,000 during the next three years.

The first project of the $30,000,000 program, completed last month, involved extension of crude oil transportation facilities into Duck Lake field in St. Martin Parish in southwest Louisiana.

The second project, now under way, involves the complete replacement of the present Bunkie, Louisiana, pump station with a new one of modern design. The present Bunkie station was built in 1909-10, and in later years has been increased in capacity several times.

The other projects include expansions of Interstate's crude oil pipe line system planned for south and southwest Louisiana.



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Sarnia-London Line in Operation; to Be Extended

Initial flow of gasoline through the Imperial Oil Company, Ltd., pipe line, lately completed from Sarnia to London, Ontario, a distance of 65 miles, was effected March 15 and delivery to the terminal tanks at the latter manufacturing city established on the 18th. It required three days to fill the line to its capacity of 1,700,000 gal.

Extension of the line another 123 miles to Toronto, with Hamilton, "Canada's Pittsburgh" and another port on Lake Ontario, is looked for during the coming summer. This Sarnia-London section has cost $4,250,000 and the 188-mile total is estimated at $10,000,000.

Present delivery at London is of two grades of gasoline, but when full storage capacity of 215,000 bbl becomes available, five major products—regular and premium gasolines, diesel oil, stove and furnace fuels—will be transmitted. Two 29,000-bbl tanks already have been built at London and four other tanks will follow as soon as steel can be obtained for the project.

London deliveries, starting at a rate of about 10,000 bbl a day, will increase with completion of the line to Toronto and capacity of 39,000 bbl daily is established, with an initial throughput of 22,000 bbl. The line capacity is capable of expansion to 49,000 bbl per day by the construction of an additional pumping station at London.

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Bert Hull Associated With West Coast Pipe Line

Bert E. Hull, retired president of The Texas Pipe Line Company, and now a consultant on pipe line construction, has associated himself with the West Coast Pipe Line Company, organized two years ago to build a crude oil pipe line from West Texas to California. He is chairman of the board and executive vice president of the company. West Coast Pipe Line Company has its headquarters in Dallas, Texas, and, in addition to Hull, the officers are: L. M. Glasco, president; Joe A. Humphrey, vice president, and Ray Hubbard, secretary-treasurer. All are independent oil operators of Dallas.

The company's application now before the Petroleum Administration for Defense asks for permission to lay a 984-mile, 20-in. line from Wink, Texas, to Norwalk, California. It would have an initial capacity of 180,000 bbl a day and would cost an estimated $75,000,000. Washington approval has not yet been granted.

Progress Pacific Pipe Line Company of Los Angeles also is asking PAD approval for a pipe line from West Texas to the Pacific Coast. Its application is for a 24-in., 1050-mile line from Odessa, Texas, to Long Beach, California, at an estimated cost of $120,000,000. This firm plans a parallel 10-in. products line.

Hull's association with West Coast Pipe Line is the fourth such he has made. Earlier he was retained by the Texas-Ohio Gas Company, Houston, United States Pipe Line Company, New York, and Coastal Products Pipe Line Company, Houston.

Interprovincial Awards 100-Mile Loop Contract

A contract to construct approximately 100 miles of pipe line through the central division of the Interprovincial Pipe Line Company has been awarded, R. E. Trammell, general manager, announces. Anderson International Contractors, Ltd., of Edmonton, Alberta, are to install the pipe line "loop".

The contract calls for the construction of a second 16-in. pipe line through 100 miles of the present 334-mile, 16-in. line system that extends from Regina, Saskatchewan, to Gretna, Manitoba. Divided into two portions, the program, when completed, will increase the capacity of the Regina to Gretna section from 101,750 bbl a day to 120,000 bbl a day.

One complete "spread" will lay the new pipe on the present right-of-way and 10 ft to the north of the existing pipe line.

Although it is planned to get work underway June 1, the actual starting date will depend on frost conditions at that time. Pipe has been ordered from Page Hersey Tubes, Ltd., of Welland, Ontario, and it is expected that the first pipe will be delivered on to the sites during the first week of May. The complete looping project will cost approximately $5,500,000.

Pipe Line Personals

S. R. Simmons

S. R. Simmons, manager of the Southern Division of Interstate Oil Pipe Line Company, Shreveport, Louisiana, has been elected a member of the board of directors, Joseph L. Seger, Interstate president, announces. Simmons assumes the board position vacated by S. W. Day, vice president, who retired March 1 after almost 47 years of service with Interstate and its predecessor companies.

Simmons is a veteran of 39 years pipe line experience, having been first employed as a station oiler at Oxford Station, Louisiana, by the pipe line department of Standard Oil Company of Louisiana in 1913.

Until called to active military service during World War I. Simmons served as station oiler and station engineer at Oxford, Moore and Bunkie stations on the Arkansas-Baton Rouge main line system.

During World War I he served 18 months as commanding officer of the 154th Aero Pursuit Squadron, with one year of this period being spent overseas.

Upon termination of his military service in February, 1919, he resumed his pipe line employment with Standard Oil Company of Louisiana, serving temporarily as chief engineer at Moore and Oxford stations before moving to Bunkie station for almost 17 years. At Bunkie, Simmons served as station chief engineer, general foreman, and later district foreman.

From April, 1937, to January 1, 1945, Simmons served in the capacities of assistant superintendent and assistant general superintendent of the pipe line department with headquarters in Shreveport, Louisiana.

On January 1, 1945, when Standard Oil Company of Louisiana's pipe line properties were acquired by Interstate Oil Pipe Line Company, he was named assistant general superintendent of Interstate's Southern Division embracing operations in Arkansas, Louisiana, and Mississippi.

Simmons was promoted to general superintendent of the Southern Division on January 1, 1946, and in 1949 was assigned additional duties as assistant manager of the division. He was elevated to his present position as division manager on September 1, 1951.

Sidney Feldman has joined the American Gas Association public information staff as a special writer. He replaces **John J. Hassett,** who resigned to become public relations director of a Washington trade organization. Feldman, who will concentrate on national publications for AGA, has been a regular contributor to "The New York Times" magazine, "The Office," and "Steelways," as well as having written articles for The Encyclopedia Americana, Popular Photography, among others, and several European newspapers during a freelance trip abroad.

In addition to being reporter and feature writer for "The Standard-Times" of New Bedford, Massachusetts, Mr. Feldman was editor of "Safety" magazine published by The Greater New York Safety Council.

P. D. Funderburk, station chief engineer at Monahans, Texas, for Shell Pipe Line Corporation, has been promoted to district gager, and will continue to be stationed at that place.

R. F. Johnson, field maintenance mechanic at Odessa, Texas, has been made mechanical maintenance supervisor at Rankin.

Justin Griffin has joined the measurement department of Texas Eastern Transmission Corporation, Shreveport, Louisiana, as assistant to **P. H. Miller,** measurement superintendent. Since graduating from Centenary College in 1933 with a BS degree in chemistry, Griffin has been employed by Arkansas Fuel Oil Company, where he was chief chemist, by United Gas Pipe Line Company as gas laboratory supervisor, and by Atlas Processing Company as chief chemist. As assistant measurement Griffin will be active in gas measurement, gas quality measurement and control, and corrosion control.

R. C. Turner has been named vice president of British-American's Alberta Pipe Line Limited and manager of British-American's Western Crude Oil Purchasing Division. He replaces **R. H. C. Harrison,** who has become president of the Western Canada Petroleum Association.

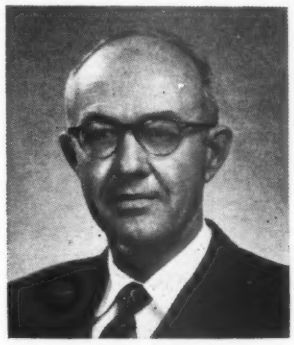
Turner entered the employ of Toronto Pipe Line Company in 1946 as a district gager in the South Texas district. Late in 1947 he became a crude oil scout working out of the Tulsa, Oklahoma, office. He was transferred to the Canadian company in December, 1950, as general superintendent of pipe line operations in western Canada.

George S. Schonewald has been transferred by the Eastern Pipe Lines Division of Socony-Vacuum Oil Company, Inc., from Plainfield, New Jersey, to the New England Division as technical assistant to the division superintendent, **J. B. Hickey.** His new headquarters are in Portland, Maine.

Charles Fitzgerald, Fort Worth, Texas, and **H. J. Amend,** Independence, Kansas, have been elected directors of the Sinclair Pipe Line Company.

Charles O. Davis has been named superintendent of operations in the Michigan division of Pure Transportation Company. He will succeed **C L. Bernard,** who will accept increased responsibilities in Oklahoma. Davis, formerly assistant superintendent of the division, has been with Pure Oil Company for 27 years. **Clair E. Cox** succeeds Davis as assistant superintendent, and he and Davis will have offices in Mount Pleasant.

George C. Dormer was named assistant chief engineer for Manufacturers Light and Heat Company and associated Pittsburgh Group gas companies in the Columbia Gas System. He has been assistant superintendent of production-transmission Division No. 7 in Binghamton, New York. **A. B. Lauderbaugh,** chief engineer is supervising gas-company engineering programs.



E. A. Koenig

E. A. Koenig, general superintendent for Texas Eastern Transmission Corporation, has received a leave of absence to accept a one year appointment effective immediately as chief, Gas Transmission Branch, Gas Operations Division, Petroleum Administration for Defense, in the U. S. Department of Interior at Washington, D. C. E. R. Cunningham, vice president in charge of operations made the announcement. Koenig will serve in Washington without compensation and in his absence **H. M. McDonald,** superintendent of pipe lines, will act as general superintendent.

Koenig has had wide experience in the natural gas, oil and pipe line industries, extending over the past 28 years, and has served with Texas Eastern in Shreveport since April 1947.

With the PIPE LINE CONTRACTORS

River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas, has the following spreads working for United Gas Pipe Line Company on a project that, overall, consists of approximately 1000 miles of pipe line in Texas, Mississippi, and Louisiana:

Natchitoches, Louisiana — H. J. Tatom, superintendent; H. C. Arthur, assistant superintendent; A. L. Price, office manager, and Paul Whitehead, master mechanic.

Liberty, Texas—B. C. Hall, superintendent. Working on crossing of Houston Ship Channel and Crystal Lake. Banty Traweek in charge of crossings, Borger Red McMenamy of land lines.

Jasper, Texas—Jimmy Reid, superintendent, and Pat Rogan office manager.

Monroe, Louisiana — Laying 30-in. pipe between Sterlington station and Natchitoches. Merl Tatom, superintendent, and Earl Nevins office manager.

Cleveland, Texas — River crossing spread in charge of Charlie Simmons.

Jake Minyard is general superintendent for River Construction with headquarters in Fort Worth, P. O. Box 9127. Office phone is Sunset 6518 and the warehouse Sunset 2104.

Williams-Austin Company, Grant Building, Pittsburgh 19, Pennsylvania, has the following work for the New York State Natural Gas Corporation:

12 miles 20-in. loop line at Zelienople, Pennsylvania. Start April 15, completion May 15. Warehouse at Zelienople, Pennsylvania. Ralph Gaddy, superintendent, E. E. Mayes, timekeeper.

52 miles 16-in. from Utica, New York, to Amsterdam, New York. To begin at completion of Zelienople job. Ralph Gaddy, superintendent, L. A. Franks, timekeeper. Completion in 90 days. Warehouse at Herkimer, New York.

20 miles 20-in. from Cayuta Gate to Ithaca, New York. Start May 1, completion June 30. Warehouse at Ithaca, New York. Howard Bauer, superintendent, R. H. Condry, timekeeper.

20 miles 20-in. from Angelica, New York, to Rossburg, New York. To start at completion of Cayuta Gate-Ithaca job, completion in 45 days. Howard Bauer, superintendent. Warehouse to be determined later.

17 miles 16-in. from Colesburg Junction to Sabinsville, Pennsylvania. To start at completion of Angelica job. Howard Bauer, superintendent.

Ed Peters is general superintendent. The field warehouse is at Cortland, New York, Phone 23.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, has completed all pipe laying in Wyoming on the Platte Pipe Line Company system and is now working eastward from the Wyoming-Nebraska state line. The field office is at Scottsbluff, Nebraska. A. A. Carrigan is superintendent and Dave Wagner office manager.

Two spreads are working on the Sinclair Pipe Line Company job from Humboldt, Kansas, to Salisbury, Missouri, 180 miles of 24-in. One spread has its headquarters at Iola, Kansas, where M. L. Boyd is superintendent and Vance Albers office manager. The second spread is working out of Warrensburg, Missouri. Jerry Nash is superintendent and Chuck Sievert office manager.

Williams Brothers Corporation, National Bank of Tulsa Building, Tulsa, Oklahoma, has recently contracted to lay 145 miles of 26-in. in Venezuela for Creole Petroleum Corporation. The line will extend from Ulé station on the east side of Lake Maracaibo to Amuay Bay. Marvin Jones will be in charge and the job is expected to get underway about June 1.

Work has begun on 143 miles of 10, 24, and 26-in. for Algonquin Gas Transmission Company in New York, New Jersey, and Connecticut. The central office is at Danbury, Connecticut, with R. L. Buck general superintendent. Spread offices are at Summerville, New Jersey, with O. R. Mitchell spreadman, Suffern, New York, with Whitey Martin spreadman, and a third spread will have its field office somewhere in Connecticut with T. E. "Thelma" Davis in charge.

Thirty miles of 26-in. was scheduled to get underway May 1 for Minneapolis Gas and Light Company in the City of Minneapolis. W. F. Caldwell is superintendent.

The laying of 18 miles of 6 and 8-in. began at Greenville, South Carolina, in April for the Piedmont Natural Gas Company. Brownie Young is in charge.

Delay of pipe shipments has held up the start on 14 miles of 3, 4, and 6-in. for Public Service Company of North Carolina at Adenville and Belmont, and 20 miles of 4-in. at Mooresville, Kanapolis, and Concord.

Gulf Southern Contractors, 516½ Louisiana Avenue, Shreveport, Louisiana, have the overall contract to lay approximately 1000 miles of pipe line for United Gas Pipe Line Company in Louisiana, Texas, and Mississippi. Gulf Southern is a contracting group consisting of River Construction Corporation, Fort Worth; Oklahoma Contracting Company, Dallas; J. Ray McDermott and Company, New Orleans, and Morrison-Knudsen Company, Boise, Idaho.

Somerville Construction Company, Ada, Michigan, is laying an 18-mile, 16-in. loop around Peoria, Illinois, for Central Illinois Light Company. Work began March 17 with Jim Godwin in charge. A second spread under Pete Huner moved on the job April 15. The job is scheduled for completion in June.

Houston Contracting Corporation, 2707 Ferndale Place, Houston, Texas, has the following construction work under contract:

Approximately 220 miles of 22-in. crude oil pipe line for The Texas Pipe Line Company from the vicinity of Houma, Louisiana, to Port Arthur, Texas. This work is being handled by three spreads, all of which started laying pipe March 15.

67 miles of 22-in. from vicinity of Holmwood, Louisiana, west to Port Arthur Texas. E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, field office manager. Headquarters, Lake Charles, Louisiana.

67 miles of 22-in. from vicinity of Holmwood, Louisiana, east to Gueydan, Louisiana, and from Morgan City, Louisiana, east to Houma, Louisiana. W. H. Hayes, superintendent; M. L. Thompson, assistant superintendent; J. C. Strickler, field office manager. Headquarters, Jennings, Louisiana.

86 miles of 22-in. from vicinity of Gueydan, Louisiana, east to Morgan City, Louisiana. F. A. Silar, superintendent; C. V. Oliver, assistant superintendent; L. F. Redfearn, field office manager. Headquarters, Abbeville, Louisiana.

Approximately 95 miles, consisting of 30 miles of 12-in., and 65 miles of 10-in., 8-in., and 6-in., crude oil pipe lines for The Texas Pipe Line Company from Houma, Louisiana, south to and through the Terrebonne Bay vicinity. H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; H. C. MacWhinnie, field office manager. Headquarters, Houma, Louisiana. Started laying pipe March 10.

Five major river crossings for The Texas Pipe Line Company from the vicinity of Morgan City, Louisiana, west to Orange, Texas. J. A. Cantrell, superintendent; J. B. Stoddard, field office manager. Headquarters, Orange, Texas.

Approximately 190 miles of 24-in. crude oil line for Rancho Pipe Line Company from a point west of Austin, Texas, to Shell Oil Company's Deer Park Refinery. Preliminary work to start in May, 1952.

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, has under construction 120 miles of 26-in. between Granbury and a point about 15 miles west of Abilene, Texas, for the West Texas-Gulf Pipe Line Company. Two spreads are at work. The one under L. H. Gray has moved its headquarters to Ranger. Jack Bradley is office manager and M. B. Gregory master mechanic. The second spread is now at Abilene. W. A. Briley is superintendent, Buck Johnson office manager and J. D. Jackson master mechanic.

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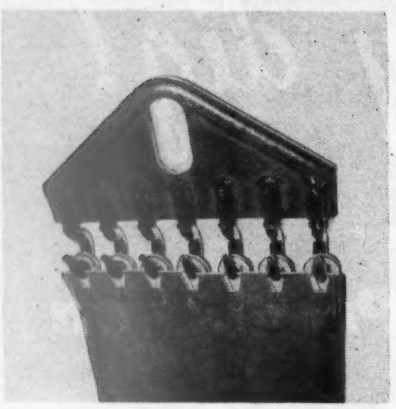

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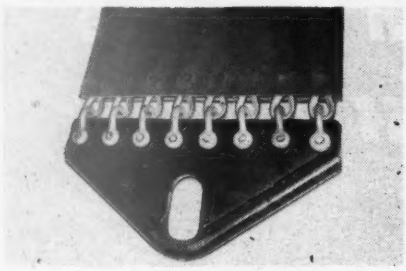

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Smith Contracting Corporation, 205 Northwest Seventh Street, Fort Worth, Texas, although delayed somewhat by rain, had laid 47 miles of 16-in. pipe to April 17, on The Texas Pipe Line Company job from Corsicana to East Houston, Texas. The north spread, which will lay 88 miles between Corsicana and Madisonville, had laid 40 miles. Field headquarters are at Teague with Frank Craig superintendent and M. E. Williams office manager.

The south spread, which has the 88-mile section from Madisonville to East Houston, was just getting underway in good shape and had completed 7 miles. Pat Erwin is superintendent and John Briggs office manager. Art Renton is engineer and purchasing agent for both spreads.

H. C. Price Co., P. O. Box 1111, Bartlesville, Oklahoma, has signed a contract with Brown and Root, Inc., agents for the Texas Eastern Transmission Corporation, for construction of an undetermined number of miles of 30-in. pipe line in Ohio, West Virginia, and Pennsylvania. Two spreads have been moved to the location. Right-of-way work got underway April 7, and pipe laying the middle of April.

A spread under Superintendent R. K. Shivel is making headquarters in Moundsville, West Virginia, and is working eastward from Texas Eastern's crossing on the Ohio River. A second spread under Superintendent Charlie Ice is at Woodsfield, Ohio, and is working westward from the Ohio River.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, continues work on 154 miles of 24-in. line for Sinclair Pipe Line Company, between Cushing, Oklahoma, and Humboldt, Kansas, as part of Sinclair's new crude oil line from Cushing to East Chicago, Indiana. The spread under A. B. Haynes, working out of Chanute, Kansas, has completed its section. Floyd W. Lewis and his crew are making their headquarters at Hominy, Oklahoma. Virgil Lambert, in charge of river crossing construction, also has his headquarters at this point. Walt Hill is office manager.

For Platte Pipe Line Company, 120 miles of 20-in. pipe are being laid from Salisbury, Missouri, and to the Missouri River south of St. Joseph, Missouri. The field office is at Carrollton. B. W. Moore is superintendent, Howard Smith office manager, and A. L. Lundberg master mechanic.

H. B. Zachry Company, 1100 Transit Tower, San Antonio, Texas, expects to complete about May 10 the 24 miles of 30-in. being laid for Texas Eastern Transmission Corporation in the vicinity of Morehead, Kentucky. D. B. Shrum is field superintendent and Ray Shields office manager. Foremen of the various operations are as follows: Billy Cole, back end; W. L. Huff, front end; Walt Stowell, right-of-way; Bozo Carney, ditch; Dale Croan, bending; Dick Wroten, pipe; Benny Price, welder; John Massey, dope; Red Long, lower in; Pee Wee Johnson clean-up, and Jack Franklin, road crossings.

Smith-Donaho Contracting Company, 205 Northwest Seventh Street, Fort Worth, Texas, recently completed 41 miles of 10-in. for Phillips Pipe Line Company between Paola, Kansas, and Warrensburg, Missouri. This is a products line. Herb Smith was superintendent in charge, H. E. Doyle spreadman, and Ernest Bell office manager.

Rumsey Brothers Pipe Line Construction Company, 4039 North Boulevard, Wichita, Kansas, will lay 100 miles of 20-in. on the Platte Pipe Line Company system, from the Nebraska-Kansas state line near Lanham, Kansas, to the Missouri River near Doniphan, Missouri. The contractor is waiting on pipe.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, has completed the installation of a compressor unit at Tuscola, Illinois, station of Panhandle Eastern Pipe Line Company. The two units being installed at Edgerton, Indiana, are about completed. K. L. Kreamalmyer is in charge.

On the process piping work being done for Aluminum Ore Company at Bauxite, Arkansas, the fabrication work is 20 per cent completed and the installation work 10 per cent.

Earl S. Powell is superintendent; F. C. Snavely, Jack Graham, and Elwood Rolf, area superintendents; and Morris Garey, office manager.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, has put five spreads on the Texas Eastern Transmission Corporation job, which consists of 217 miles of 30-in. from Portsmouth, Ohio, to Connellsville, Pennsylvania. The spreads are located as follows:

No. 1—Oak Hill, Ohio. Emmett Wilkerson superintendent, Kelly Strickland office manager, Jodie Travis master mechanic, and Leroy Jackson assistant superintendent.

No. 2—Athens, Ohio. G. Caldwell, superintendent and George Fleming office manager.

No. 3—Beverly, Ohio. Earl Hackelman superintendent, C. C. Lazier office manager, and Freddy Younts master mechanic.

No. 4—Caldwell, Ohio. Rusty Killingsworth superintendent, Russell McDowell office manager, and C. L. Fleming master mechanic.

No. 5 — Uniontown, Pennsylvania. Earl Saulsman superintendent, O. J. Vincent assistant superintendent, Frank Hindman office manager, and Joe Sloss master mechanic.

The central office for all spreads is at Marietta, Ohio. Dick Leonard is general superintendent, R. A. West project manager, and Mike Keady office manager.

For the Rancho Pipe Line Company, 267 miles of 24-in. pipe is being laid from McCamey to Cedar Valley, Texas. The field office is at McCamey. Aldress Kilgore is superintendent, Karl Smith office manager, and Jimmie Middleton master mechanic.

Anderson contracted 154 miles of the 26-in. crude oil line of West Texas-Gulf Pipe Line Company, a 94-mile section between Granbury and Wortham and a 60-mile section from Abilene to Colorado City. W. H. "Cooney" Shiflett is superintendent of the spread laying the former section and has his field office at Hubbard. Fred Pervis is office manager. The field office for the Abilene-Colorado City section is at Sweetwater, where Gene Coulter is superintendent and Dick Bond office manager.

M. E. "Panama" Shiflett is general superintendent over all spreads operating in Texas.

Anderson International Contractors, Ltd., Edmonton, Alberta, Canada, has been awarded a contract by the Interprovincial Pipe Line Company to lay a 16-in., 100-mile loop to its system. The loop will be in the central portion of the system. Work is expected to get underway about June 1.

Bishop and Lock Construction Company, 1018 Magnolia Building, Dallas, Texas, expects to complete between May 1 and 10 the gathering system it is laying in the Pegasus field of West Texas for Magnolia Pipe Line Company. The system consists of 82 miles of 3½-in. through 24-in. pipe. The construction crew is working from Odessa, Texas, with Howard Laquey superintendent and R. B. Pryor office manager.

Western Construction Company, P. O. Box 1135, Hobbs, New Mexico, has contracted to take up 50 miles of 8-in. and lay the same amount of pipe for Continental Pipe Line Company between Port Isabel and McAllen, Texas. The field office is at Harlingen. Morris Lassley is superintendent in charge.

Mahoney Contracting Company, 2300 North Grand Avenue, Lansing, Michigan, has contracted to lay gathering and repressuring lines in the vicinity of Mansfield, Ohio, for Ohio Fuel Gas Company. The mileage is undetermined.

Still to be completed is the 95 miles of 8-in. through 24-in. pipe for Michigan Gas Storage Company between Laingsburg and Mt. Clemens, Michigan. This work was shut down during the winter months. The field office is at Rochester. Barney Finnerty is superintendent and Al McConnell office manager.

J. L. Cox and Son, Raytown, Missouri, are stringing 154 miles of 24-in. pipe for O. R. Burden Construction Corporation on the Sinclair Pipe Line Company system between Cushing, Oklahoma, and Humboldt, Kansas. Melvin Thompson and Fred Osterman are the foremen.

This company has been doing considerable stringing on the Platte Pipe Line Company system, having contracts totaling 280 miles between Wood River and Kenmoor. J. L. Lyerla is foreman.

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Roskote's drying speed, its handling ease and its high electrical resistivity makes it the ideal mastic for pipeline protection, winter or summer. Whether you are protecting distribution and service lines, or large transmission lines in yard or field, it will pay you to investigate . . .

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Used by over 70 utilities and pipeline companies for coating at "hot spots," road crossings, for valves, joints, meters, drips; for patching and for waterproofing concrete regulator pits.

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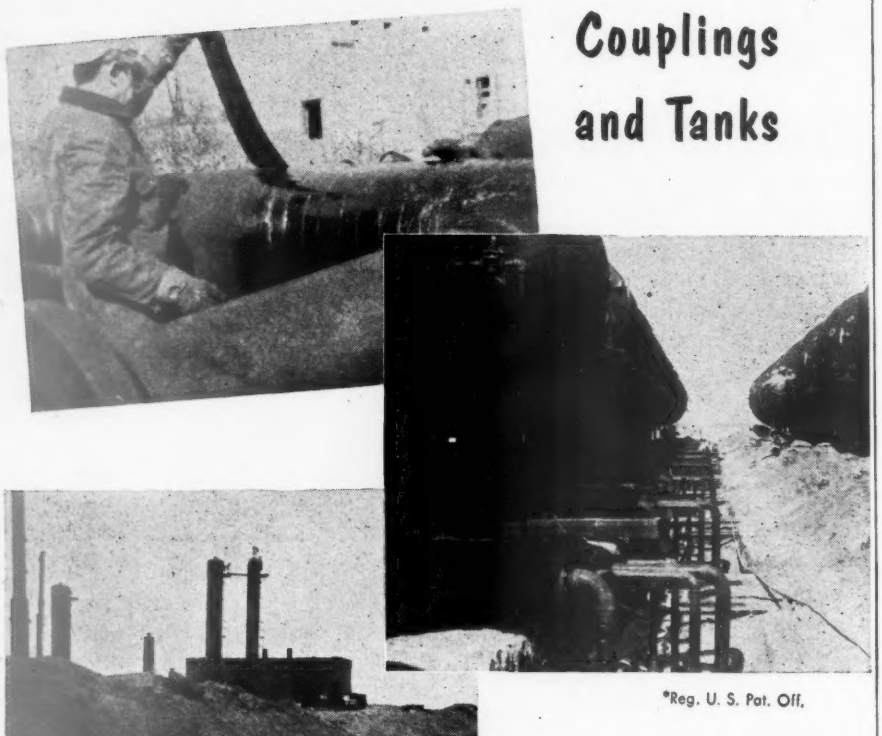

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TAPECOAT is quick and easy to apply with the use of a torch to bleed the coating and insure a perfect bond. It is sized to the job in widths of 2", 3", 4", 6", 18" and 24". Wrapping is done spirally with widths up to 6", and "cigarette-wrapped" in the larger sizes.

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Originators of Coal Tar Tape Protection

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Comstock Midwestern, Ltd., 206 Laird Drive, Leaside, Ontario, Canada, expects to begin laying pipe about May 10 on the 472 miles of 24-in. for Trans Mountain Oil Pipe Line Company. Overall this will be a 693-mile line from Edmonton, Alberta, to Vancouver, British Columbia. The contractor will lay the eastern and western portions of the system. Present plans call for a spread at Jasper, Alberta, under Joe Works, one at Red Pass Junction, Alberta, in charge of E. A. Works, and a third at Vancouver. Two main project offices have been opened, one at Vancouver with Mike Seville in charge and the other at Edmonton with Walter Fernandez in charge.

For Sarnia Products Pipeline Company, subsidiary of Imperial Oil, Ltd., 120 miles of 6, 10, and 12-in. pipe are being laid from London to Toronto, Ontario. The field office has been moved to Woodstock, Ontario. Denver Franklin is superintendent and Alma M. King office manager. Operations have been shut down but will reopen about the middle of May.

Western Pipe Coating Company, Inc., P. O. Box 181, Iola, Kansas, is sub-contractor for coating and wrapping the Sinclair Pipe Line Company 24-in. line between Cushing, Oklahoma, and Humboldt, Kansas, a distance of 154 miles. The prime contractor is O. R. Burden Construction Corporation. C. M. "Peewee" Vaughan is superintendent and H. W. Carey foreman of the south spread, which has the section from Cushing to Caney, Kansas. The north spread, from Caney to Humboldt, is in charge of Cecil D. Carey as superintendent and T. W. Branstetter foreman. Ralph Sinclair is office manager for both spreads.

Altgelt Construction Company, Inc., P. O. Box 1402, Corpus Christi, Texas, is engaged in construction of 25 miles of 4-in. through 16-in. gathering system in the Agua Dulce, Texas, area for United Gas Pipe Line Company. The field office is at Robstown, with Lee Phillips superintendent and Art Roberts office manager.

Pipe Line Construction and Drilling Company, Camp Hill, Pennsylvania, has under construction 23 miles of 16 and 20-in. for New York State Natural Gas Corporation. The field office is at Waynesburg with M. E. McClure the superintendent and Don Hill office manager.

For Tuscarora Oil Company, Ltd., 46 miles of 10-in. pipe are being laid from Midland to Russelton, Pennsylvania. The field office is at Sewickley. M. L. Foudray is superintendent and Fred Droddy, Jr., office manager. This job is scheduled for completion the latter part of May.

For the Peoples Natural Gas Company, approximately 100 miles of 6 and 8-in. pipe is being taken up between Center Bridge and Reading, Pennsylvania. The field office is at Buckingham Valley. Lee Ross is superintendent and William F. Johnson office manager.

Oklahoma Contracting Company, 6512 Hines Boulevard, Dallas, Texas, has contracted to lay 68 miles of 24-in. on the Rancho Pipe Line Company system as a joint venture with Houston Contracting Corporation. The section will be from the Shell Refinery at Houston to the Brazos River west of Katy, Texas, and work is expected to begin sometime between May 1 and 10. Raymond Law will be in charge and will have his headquarters in Houston.

Work continues for United Gas Pipe Line Company in South Texas. The spread under Louis Visentine is still working from Rosenberg. Visentine has as his assistant superintendent Buck McIntyre with Dick Mueller managing the field office. Raymond Law's spread has its headquarters at Sinton. Henry Turner is handling the office. Ed Flannagan has his headquarters at Victoria. His crew has completed the Trinity River crossing and is now doing odds and ends work, creek crossings, etc.

Fulton and Brodie Construction Company, P. O. Box 2064, Amarillo, Texas, has under construction 142 miles of 20-in. for Platte Pipe Line Company between Holdrege, Nebraska, and the Nebraska-Kansas state line near Odell, Nebraska, working from the latter point westward. The field office is at Fairbury, Nebraska. J. T. "Jake" Brodie is superintendent, Clyde Peters spreadman, and Mrs. J. T. Brodie office manager.

Lewis Montgomery Trucking Company, Box 432, Odessa, Texas, is stringing 82 miles of 3½-in. through 24-in. pipe for Bishop and Lock in the Pegasus field, Upton County, Texas. The pipe is going into a gathering system for Magnolia Pipe Line Company.

Mannix, Ltd., Calgary, Alberta, Canada, expects to begin by June 1 on the 221 miles of 24-in. pipe line that will be laid for Trans Mountain Oil Pipe Line Company, which overall will extend 693 miles from Edmonton, Alberta, to Vancouver, British Columbia. The contractor will lay the center section of the system. Cal Baker will be general superintendent, Jimmie Williams spreadman.

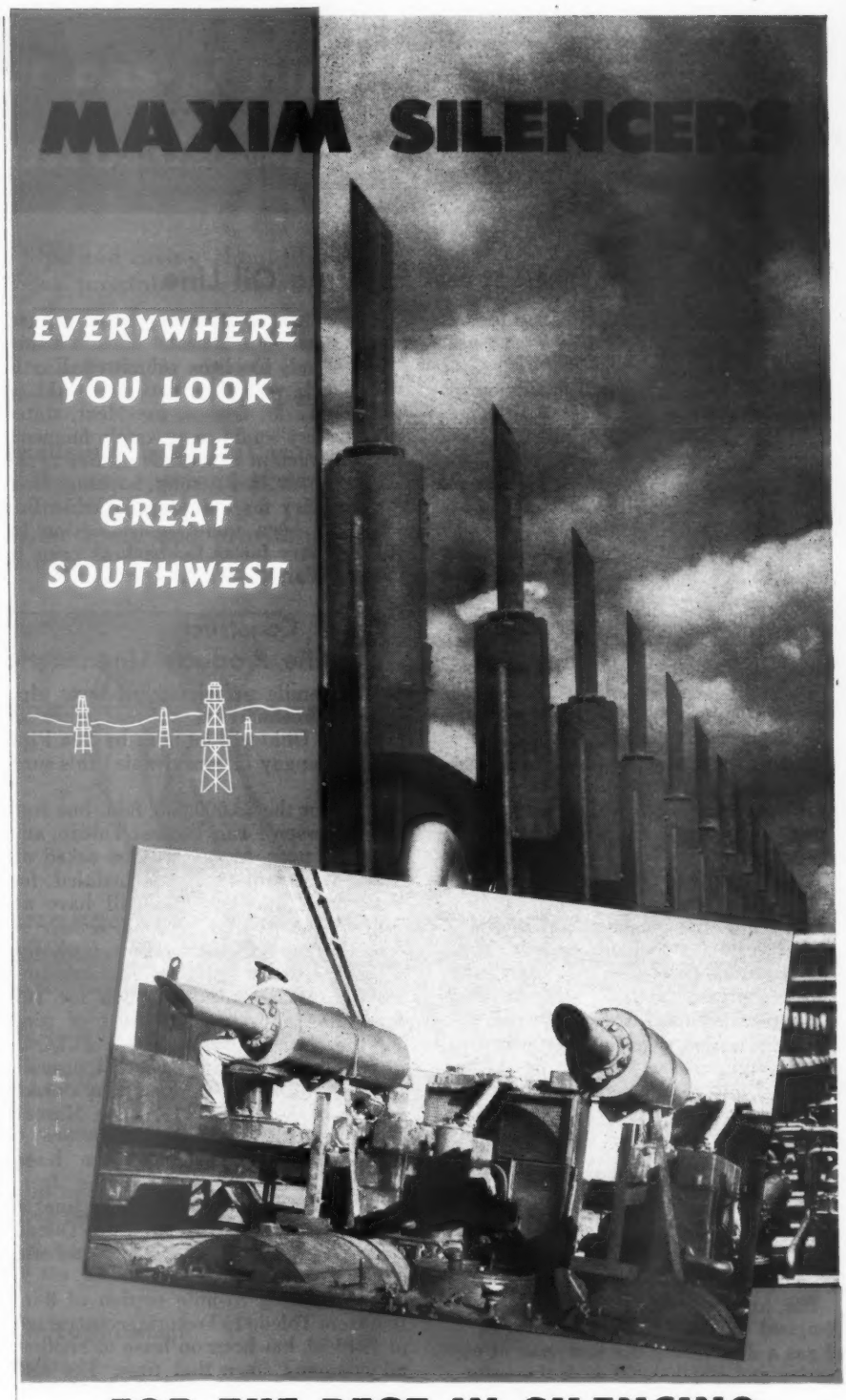
Dunn Brothers, 801 Mercantile Securities Building, Dallas, Texas, are stringing 26-in. pipe between Wortham and Nederlands on the West Texas-Gulf Pipe Line Company crude oil line.

From Rancho Pipe Line Company, 24-in. pipe is being strung from Houston to Cedar Valley, a point near Austin.

Work continues in New Mexico for the El Paso Natural Gas Company.

Latex Construction Company of Georgia, Box 56, Northside Branch, Atlanta, Georgia, has contracted 32 miles of 20-in. from Interstate Oil Pipe Line Company between Bunkie and Melville, Louisiana.

Modern Welding Company, Box 573, Owensboro, Kentucky, is installing a complete city gas system for Gallatin, Tennessee. It will consist of 40 miles of ¾-in. through 10-in. pipe. Billy Spencer is the superintendent in charge.



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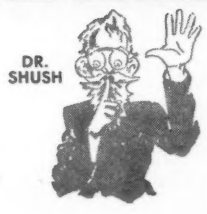

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PIPE LINE PROJECTS

PAD Approves West Texas-California Oil Line

The Petroleum Administration for Defense has given approval to West Coast Pipeline Company of Dallas, Texas, for construction of a $75,000,000 crude oil line from West Texas to California. Plans are for a 20-in., 984-mile line from Wink, Winkler County, Texas, to Norwalk, California. As part of the project, a $15,000,000 refinery will be constructed at Florence, Arizona.

PAD stipulated that engineering and financial information must be submitted to it within 90 days to obtain priority assistance on materials. This information already has been submitted, Ray E. Hubbard, secretary-treasurer, said in Dallas. L. M. Glasco, president, stated the project would be privately financed.

Construction of a crude oil line to the West Coast had strong backing from the military for some time. Such a line also has been under consideration by the industry for as far back as prior to World War II.

Permian Basin Pipeline Plans 384-Mile System

Permian Basin Pipeline Company, a new corporation, of Chicago, Illinois, has applied to the Federal Power Commission for authority to construct a 384-mile pipe line system to transport natural gas from the Permian Basin area of West Texas and eastern New Mexico to points of delivery in the Panhandle area of Texas for sale to one or more interstate pipe line companies.

The pipe line system, estimated to cost $58,180,000 would include pipe ranging from 20 to 30 in. in diam, and four compressor stations with an ultimate installed total horsepower of 74,360. The system would originate in Upton County, Texas, extend north for about 34 miles, and then northwest for 105 miles to a point in Lea County, New Mexico. From there it would extend north for 76 miles to a point in Roosevelt County, New Mexico, and then northeast for 169 miles to a connection with facilities of Northern Natural Gas Company, of Omaha, Nebraska, in Carson County, Texas.

The proposed project would have a designed capacity of 200,000,000 cu ft of gas a day during the first year of operation and 300,000,000 cu ft thereafter. The company said it is currently negotiating with respect to the sale of gas to Northern and others whose gas supply originates in the Panhandle and Hugoton fields.

Permian plans of obtain its gas supply from two primary sources — the Spraberry area of West Texas and from gas reserves in Lea County, New Mexico. The gas from the Spraberry area is residue gas obtained from natural gasoline plants and would be purchased from Phillips Petroleum Company. The gas to be obtained in Lea County is dry, or gas well, gas, and would be purchased from Gulf Oil Corporation, the Ohio Company, Plains Production Company, Amerada Petroleum Company, and Cities Service Oil Company.

Sun to Construct 110-Mile Products Line

A 110-mile petroleum products pipe line interconnecting existing lines in northern Ohio will be built by Sun Pipe Line Company (Pennsylvania) this summer.

Bids for the $3,000,000, 8-in. line running between Fostoria, near Toledo, and Hudson, near Akron, will be asked on June 1. Completion is scheduled for September 30. The line will have an initial capacity of 17,000 bbl a day.

According to Sun Pipe Line, a wholly-owned subsidiary of Sun Oil Company, the Petroleum Administration for Defense has approved allotment of pipe for the project.

Installation of the line will provide the last link in Sun Oil Company's products system, tying together its Marcus Hook and Toledo refineries.

Heretofore, products have been pumped westward to Cleveland from Marcus Hook. When the new line is completed, it is expected that Toledo refinery will supply both Cleveland and Youngstown-Akron area.

The existing 37-mile section of 8-in. line from Toledo to Fostoria, constructed in 1949-50, has been on lease to another oil company since that time. The section will be returned to Sun Pipe Line Company on completion of the Hudson-Fostoria link.

Short Lines Asked for Eastern Missouri

Associated Natural Gas Company, of Tulsa, Oklahoma, has filed an application with the Federal Power Commission requesting authority to construct pipe line facilities that would be used to supply natural gas to several communities in eastern Missouri.

The company proposes to build a total of about 32 miles of pipe line to provide service to Jackson, Portageville, Gideon, Morley, Spoonerville and Bernie. Estimated cost of the construction is $894,320.

Lone Star Gas to Lay Line in North Texas

The Federal Power Commission has ordered that a certificate of public convenience and necessity be issued to Lone Star Gas Company, of Dallas, Texas, authorizing it to acquire from Martin Wunderlich and Lee Aikin and operate such of the facilities in the Wichita Falls district as are subject to the jurisdiction of the commission and further authorizing Lone Star to construct and operate additional facilities to meet future market demands of the combined Wichita Falls area.

The facilities bought by Wunderlich and Aikin from the United Gas Pipe Line Company and now acquired by Lone Star Gas Company include approximately 678 miles of pipe line extending from Wheeler County to Young County, Texas, together with certain properties of United Gas Corporation and Union Producing Company in and around its Wichita Falls district.

Lone Star, in addition to acquiring these properties, proposes also to construct approximately 69.5 miles of 20-in. transmission line extending from the outlet of a dehydration plant in Garvin County, Oklahoma, to Lone Star's Petrolia compressor station in Clay County, Texas, and in addition to construct gathering lines, miscellaneous well and field lines, and dehydration plants. The total cost of all the facilities to be constructed is estimated at $4,010,200.

Gulf-Michigan Permitted To Withdraw Application

The Federal Power Commission has permitted Gulf-Michigan Gas Transmission Corporation, of St. Louis, Missouri, to withdraw its application in which it was seeking authority to construct a 680-mile Louisiana-to-Indiana natural gas pipe line.

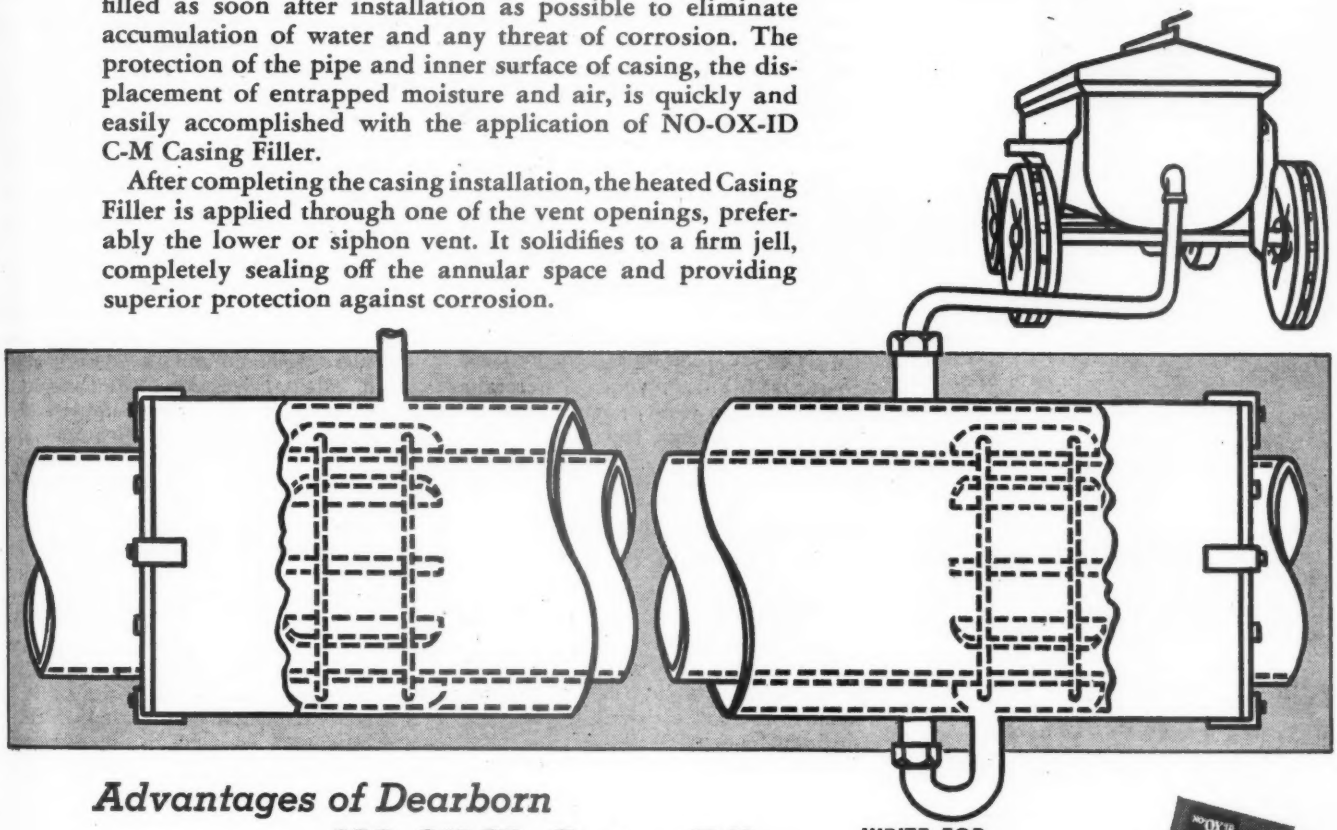
The company said that its principal reason for the withdrawal is that it has been unsuccessful in its efforts to obtain an adequate gas supply for the proposed facilities.

Gulf-Michigan had proposed to supply gas to Michigan-Wisconsin Pipe Line Company at a connection in Indiana, and to serve the St. Louis area through a lateral line extending off the main system. Estimated cost of the proposed project was $85,000,000. The system was to have had an initial capacity of 350,000,000 cu ft of gas daily, 200,000,000 cu ft of which would have been delivered to Michigan-Wisconsin, with the remaining 150,000,000 cu ft going to the St. Louis area.

How to protect cased pipe line crossings under railroads and highways

Annular space between carrier pipe and casing should be filled as soon after installation as possible to eliminate accumulation of water and any threat of corrosion. The protection of the pipe and inner surface of casing, the displacement of entrapped moisture and air, is quickly and easily accomplished with the application of NO-OX-ID C-M Casing Filler.

After completing the casing installation, the heated Casing Filler is applied through one of the vent openings, preferably the lower or siphon vent. It solidifies to a firm jell, completely sealing off the annular space and providing superior protection against corrosion.



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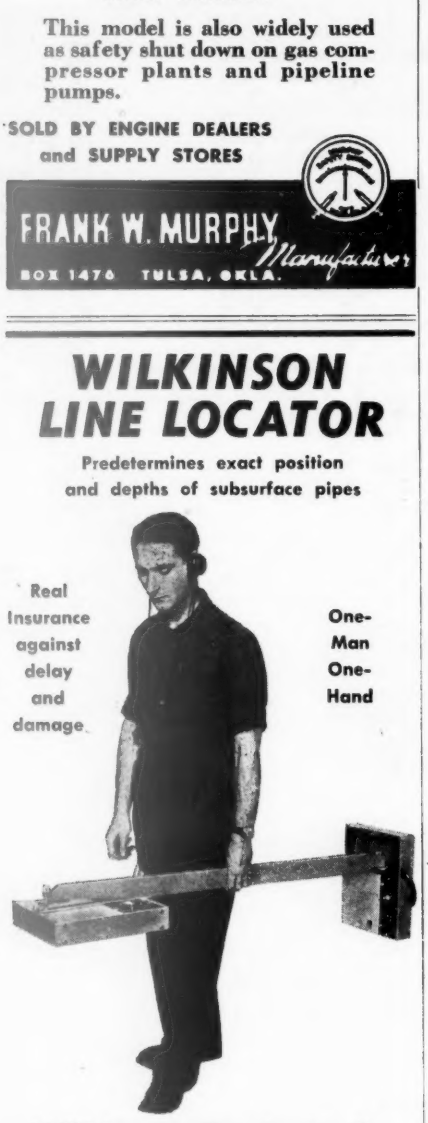

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Westcoast Files Amended Application

Westcoast Transmission Company, Inc., of Wilmington, Delaware, has filed an amended application with the Federal Power Commission in which it has revised its proposal for constructing a natural gas transmission system to serve markets in the Pacific Northwest.

As now proposed, the ultimate project will include about 349 miles of pipe line in Washington and Oregon, and one compressor station to be built at an estimated cost of $17,142,000. The company still plans to obtain its gas supply from its Canadian associate, Westcoast Transmission Company, Ltd., which would obtain the gas from reserves in the provinces of Alberta and British Columbia.

The American company plans to construct a main line, about 277 miles long, extending south from a connection with its Canadian associate's system at a point on the International Boundary near Sumas, Washington, to Portland, Oregon, with short branches to Bellingham, Mt. Vernon, Everett, Bellevue, Seattle, Tacoma-Olympia, Centralia-Chehalis, and Kelso-Longview, all in Washington, and St. Helens in Oregon. The lateral lines would total about 72 miles in length.

The proposed system would have a designed capacity of 80,000,000 cu ft a day, and by the ultimate addition of 4000 hp compressor capacity this could be increased to 200,000,000 cu ft.

In its original application, filed November 3, 1950, Westcoast proposed to construct two main lines—the Sumas-Portland line and another extending south from the Osoyoos, British Columbia, area to serve Spokane and the Atomic Energy Plant at Hanford, both in Washington. This project estimated to cost $25,690,000, was to have had a designed capacity of 221,000,000 cu ft of gas a day in the fifth year of operation, with an initial capacity of 104,000,000 cu ft.

The amended application says that another company, Trans-Northwest Gas, Inc., will file an application with the FPC for authority to construct a line to serve Spokane and the AEC's Hanford plant. Westcoast Transmission Company, Ltd., also would supply gas to Trans-Northwest, the application says.

South Georgia Natural Plans 339-Mile Line

South Georgia Natural Gas Company, of Birmingham, Alabama, has applied to the Federal Power Commission for authority to construct a 339-mile natural gas transmission system to serve communities in southwest Georgia and northern Florida.

The proposed pipe line system, which is estimated to cost $8,273,064, would have a delivery capacity of 45,000,000 cu ft of natural gas a day.

The main trunk line would connect with the system of Southern Natural Gas Company, also of Birmingham, at a point in Lee County, Alabama, and extend in a general southeastern direction to a point near Albany, Georgia. From that point a smaller branch would extend to Tallahassee, Florida. The system would include pipe ranging from 2 to 12 in. in diam.

South Georgia said that Southern Natural has agreed to make available a maximum of 19,500,000 cu ft of natural gas per day for the proposed service. Southern Natural recently filed an application with FPC for authority to increase is system delivery capacity by 350,00,000 cu ft daily. Facilities would serve 16 cities.

Hearing in June on Canadian Gas Matter

The Federal Power Commission has postponed the hearing previously scheduled to begin April 8 in Washington, D. C., to June 16 in the proceedings involving applications by four companies proposing the importation of natural gas from Canada to serve market areas in the Pacific Northwest for the first time.

The commission at the same time consolidated for the June 16 hearing recent applications by four other companies filed in connection with plans for importing and exporting natural gas from and to Canada. The FPC said that the issues posed by all of the applications appear to be interrelated and because of the time of filing of some of the applications and amendments to others, official notice cannot be given to all interested parties for a hearing on April 8 as previously scheduled.

The four companies whose applications originally had been set for hearing on April 8 are Northwest Natural Gas Company, of New York City; Pacific Northwest Pipeline Corporation, of Houston, Texas; Westcoast Transmission Company, Inc., of Wilmington, Delaware, and Glacier Gas Company, of Butte, Montana. All applications relate to proposed natural gas service in the Pacific Northwest.

Montana-Dakota Asks To Build Compressor Station

Montana-Dakota Utilities Company, Minneapolis, Minnesota, has applied to the Federal Power Commission for authority to construct a 2640-hp compressor station in Butte County, South Dakota, to provide more natural gas for consumption in the Black Hills area of South Dakota.

The proposed station, which has a total estimated cost of $752,927, would contain four 660-hp compressor units. The company said that its present facilities are taxed to capacity during cold winter days, and that it is essential that the proposed compressor station be constructed if additional gas service is to be provided in the Rapid City- Sturgis area, designated as a critical defense housing area by the Government.

Purchase of Natural Gas Facilities Is Approved

The Federal Power Commission has authorized the purchase by Manufacturers Light and Heat Company, Pittsburgh, Pennsylvania, of approximately 136 miles of natural gas transmission lines and the 2400-hp Carnegie compressor station, all in West Virginia, from United Fuel Gas Company, Charleston, West Virginia.

The commission at the same time authorized the purchase by United Fuel from the United States Steel Company of the Carnegie compressor station, two compressor units in United's Lewis compressor station, and a dehydration plant.

Trans-Northwest Asks To Import Canadian Gas

Trans-Northwest Gas, Inc., of Spokane, Washington, has applied to the Federal Power Commission for authority to import natural gas from Canada to serve markets in eastern Washington and to export gas at the International Boundary to Trail, British Columbia.

The company proposes to purchase its supply of natural gas from Westcoast Transmission Company, Ltd., at a point on the U. S.-Canadian border near Osoyoos, British Columbia. Westcoast plans to transport the gas from northern Alberta and British Columbia. Trans-Northwest would then resell a portion of this gas back to Westcoast at a point on the International Boundary in Stevens County, Washington, for service to Trail, British Columbia.

Facilities to import gas into the U. S. would have a capacity of 100,000,000 cu ft per day, and those to export gas back into Canada, 10,000,000 cu ft daily.

What Is the World Trenching Record?

Is 17,200 ft of 22-in by 40-in. trench, dug in 9 hr, on a single, working day, by a single Cleveland Trencher, the world's trench digging record? If not, what is tops?

George W. O'Connor, head of the O'Connor Construction Company of Fromberg, Montana, claims the championship on the basis of his Cleveland Trencher's performance on October 4, 1951, during the construction of a gas pipe line from the Two-Dot gas wells to Warren, Montana, as reported by the Powell, Wyoming Tribune.

"As far as I know this is a world's record for a one unit ditcher," said O'Connor, "and most ditch men would call me a liar if I made this statement to them." Operator of the Cleveland Trencher during its record-breaking performance was Fagin Rehm of Burley, Idaho, whom O'Connor described as "the best ditcher operator in the area."

O'Connor's Cleveland Trencher is powered by an International Harvester Company UD-9 diesel engine. O'Connor reported his crew had the advantage of ideal soil for the trenching operation on the bench of Elk Basin where the company was laying 6 inch pipe.

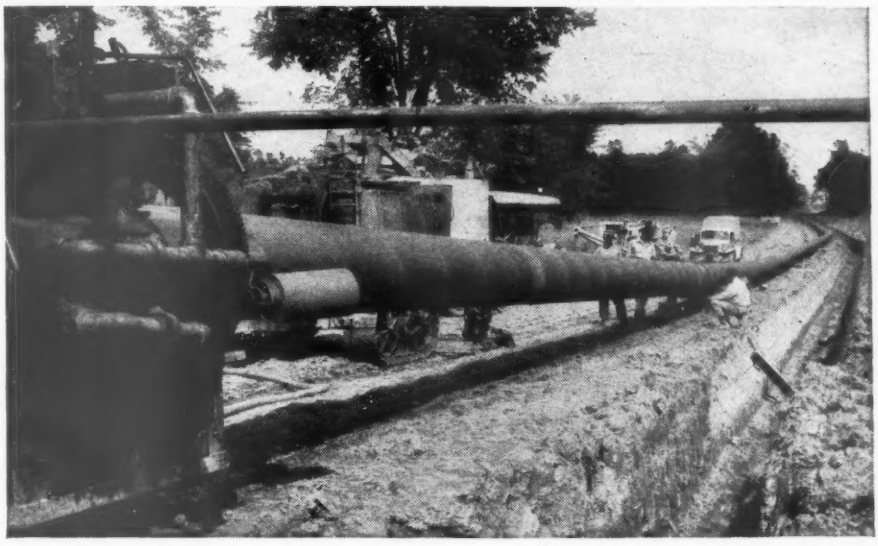
Texas Illinois Asks to Increase Its Capacity

Texas Illinois Natural Gas Pipeline Company, Chicago, Illinois, has applied to the Federal Power Commission for authority to increase the daily delivery capacity of its system from the presently authorized 374,000,000 cu ft a day to 524,000,000 cu ft.

The company is requesting permission to build six new compressor stations and additional units in existing stations to effect the 150,000,000 cu ft per day increase. The application also asks authorization for the construction of a suspension bridge across the Mississippi River and lateral pipe lines that would connect additional gas reserves to the system. Estimated total overall cost of the facilities is $52,882,000.

The new compressor stations and additional units in existing stations would be installed along the route of the company's system, which extends from Texas through Arkansas and Missouri to points near Joliet and Volo, Illinois. The six new stations each would have seven 2000-hp units, and two additional 2000-hp units would be installed at each of five existing stations, making a total additional horsepower on the system of 104,000.

Two 30-in. pipe lines would be suspended from the proposed bridge.



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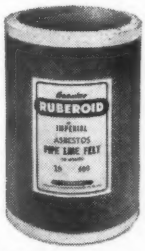

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ASPHALT AND ASBESTOS BUILDING MATERIALS

Compressor Station in Carthage Field Proposed

Tennessee Gas Transmission Company of Houston, Texas, has applied to the Federal Power Commission for authority to construct a 2640-hp compressor station in the Carthage field, Panola County, Texas.

Tennessee purchases 100,000,000 cu ft of natural gas a day in the Carthage field from The Chicago Corporation, and this gas is then transported by United Gas Pipe Line Company to a connection with Tennessee's system in Louisiana. The application says that the natural pressure of some of Chicago's gas wells has diminished to the extent that gas can no longer be delivered at the pressure required by United without compression.

Tennessee said that eventually it may be faced with the necessity of compressing the entire quantity of 100,000,000 cu ft daily, and that therefore it is necessary to provide compression facilities in the Carthage area to insure its ability to fulfill its commitments.

The proposed compressor station, which initially would contain two 1320-hp units, is estimated to cost approximately $880,000. Tennessee said that additional compressor horsepower will be required in 1955. The station would be supervised and operated for Tennessee by The Chicago Corporation.

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Propose Export of U. S. Gas to Eastern Canada

Tennessee Gas Transmission Company, of Houston, Texas, and Niagara Gas Transmission, Ltd., of Toronto, Canada, have filed a joint application with the Federal Power Commission requesting authority to export approximately 50 billion cu ft of natural gas per year from the United States to markets in the provinces of Ontario and Quebec, Canada.

Under the proposal, Niagara would purchase the gas in producing areas in the southwestern United States. This gas would then be transported by Tennessee, for the account of Niagara, to a point in the International Boundary north of Niagara Falls where the proposed facilities of the two companies would connect. Niagara would then transport the gas to markets in Ontario, including Toronto, Hamilton and Ottawa, and Quebec, including Montreal.

Tennessee concurrently filed an application for a Presidential Permit to construct, maintain, and operate the facilities at the International Boundary for delivery of the gas to Niagara. Tennessee said it is preparing an application for FPC authority to construct additional facilities on its system for the transportation of Niagara's gas within the United States.

Northern Natural Would Import Canadian Gas

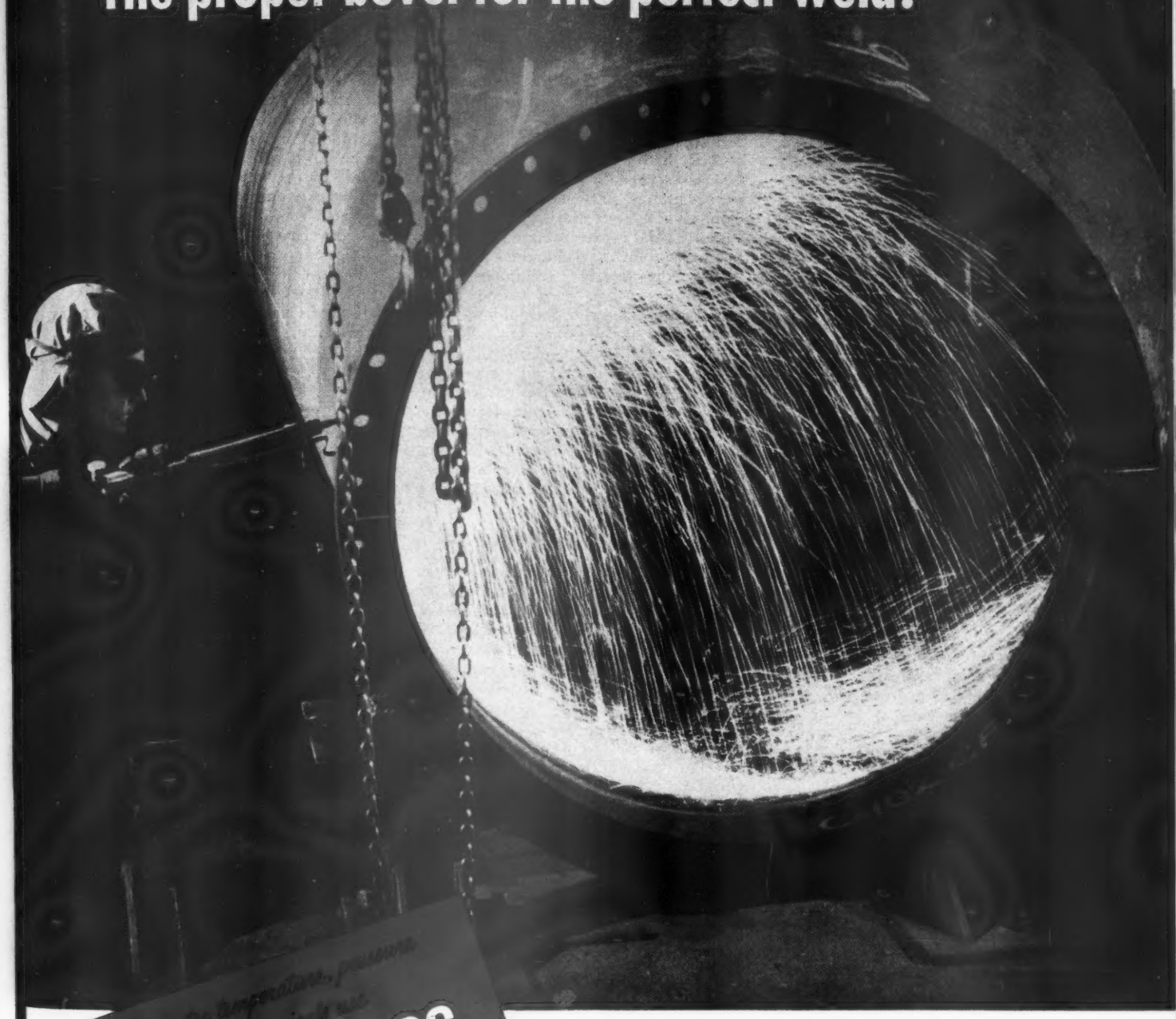
Northern Natural Gas Company, of Omaha, Nebraska, has filed an application with the Federal Power Commission proposing the construction of a 400-mile pipe line extending from the U. S.-Canadian border to a point near Minneapolis, Minnesota, to transport natural gas produced in Canada to market areas in the Midwest.

Northern's proposed project, which also includes two compressor stations with a capacity of 5280-hp each, has a total estimated cost of $24,590,000. The pipe line would transport an average of 120,000,00 cu ft of natural gas a day during the first year of operation, with the volume subsequently being increased up to a maximum of 250,000,000 cu ft.

The proposed 24-in., 400-mile pipe line would originate near Emerson, Manitoba, Canada, and extend southward along the Red River Valley to a point near Fergus Falls, Minnesota. From there it would extend in a southeastern direction to a point of connection with Northern's existing pipe line system near Minneapolis and St. Paul, Minnesota.

The gas would be purchased by Northern at the U. S.-Canadian border from Western Pipe Lines, a Canadian corporation. Western proposes to obtain its gas supply from fields in southern Alberta, and is now seeking authority from the Alberta Natural Gas Conservation Board to export gas to the provinces of Saskatchewan and Manitoba and to the United States.

The proper bevel for the perfect weld!



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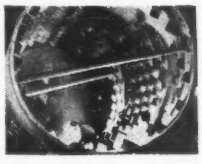

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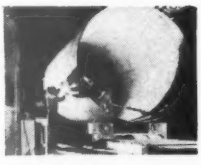

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NEWS

Chapman Lauds Companies For Fuel Oil Shortage Aid

Secretary of the Interior Oscar L. Chapman has expressed the appreciation of the Petroleum Administration for Defense to the 12 oil companies participating in the East Coast Supply Committee for their aid in averting a threatened shortage of heating oil in the New Jersey - New York - New England area last winter.

Under a Voluntary Agreement approved by Defense Production Administrator Manly Fleischmann on February 18, upon the advice of Secretary Chapman, the 12 companies agreed to provide heating oil, at the direction of PAD, over and above their regular commitments to their own East Coast customers in quantities sufficient to make up supply shortages up to a maximum of 2,930,000 bbl.

Because the companies sold the oil at East Coast ceiling prices, which were below the costs of producing, acquiring, and transporting the oil, PAD estimates that the companies sustained a substantial out-of-pocket loss, Secretary Chapman said.

U. S. Oil Imports Down

Total imports for the week ended April 12 were 790,800 bbl per day, making a four weeks' average of 891,200 bbl per day, according to an American Petroleum Institute release. This was a decided decrease from the week ending March 29, when a total of 1,056,000 bbl per day were imported.

Week ended	Crude Oil	Residual Oil	Others	Total
	(Figures in bbl per day)			
March 15	470,600	438,000	15,500	834,100
March 22	454,700	368,300	34,800	857,800
March 29	477,600	542,600	35,800	105,600
April 12	502,500	274,200	14,100	790,800
4 weeks average	466,800	392,300	32,100	891,200

Foreign Oil Men to Attend International Oil Meet

The Nomads organization and the United States Department of State will invite visitors from other oil countries of the world to attend the 1953 International Petroleum Exposition, May 14-23 at Tulsa, according to W. G. Skelly, president.

Executive secretary of the Nomads National Board of Regents, Harry E. Estes, of Houston, A-1 Bit and Tool Company, is heading the Nomads exposition committee.

Committee aides to handle various phases of the Nomads participation will be appointed within the next 30 days by Estes who will be assisted by Members of the Board from the New York, Dallas, Los Angeles, Houston, and Tulsa chapters.

The United States Department of State is to issue invitations to the various countries through diplomatic channels, according to Skelly. Oil men from 43 countries outside the U. S. attended the last show held in 1948.

WSB Turns Wage Dispute Back to Oil Companies

The Wage Stabilization Board temporarily took a back seat last month and let the Oil Workers International Union and the oil companies try again for a settlement of their wage dispute. The step was taken following futile attempts to hold "pilot" meetings with representatives of a few major oil companies.

WSB had set up two panels to hear two cases each in an attempt to reach representative settlements, but when it came time to meet, the oil companies refused to send representatives. A spokesman declared the companies objected to any "one-package" treatment of the controversies that they feared might lead to industry-wide bargaining.

President of the union, O. A. Knight of Denver, Colorado, declared the union had delayed a national oil strike three times at the request of the government, and was postponing it again. He set the last of April, however, as the final date of negotiations, declaring that if satisfactory wage settlement had not been reached by then the threatened strike would go through as scheduled.

Texas Crude Output Cut

The Texas Railroad Commission has cut the maximum oil output by 168,892 bbl of crude oil this month. This makes the total permissive oil flow 2,932,120 bbl daily, the lowest since January.

Many industry executives expressed approval of the cut at a statewide oil hearing to cope with what they described as excessive above-ground stocks. Under April allowables approximately 2,888,000 bbl daily were produced.

Pad Summarizes Priorities To Gas and Oil Projects

The Petroleum Administration for Defense up to March 28 had approved applications for priorities assistance in completion or construction by private industry of 3573 oil and gas projects having a total value of $3,516,961,284, Secretary of the Interior Oscar L. Chapman announced. PAD's first approval of such an application—known as Form PAD-26—was granted June 13, 1951.

None of these figures includes the grants of priorities assistance by PAD for purchases of materials used in drilling gas and oil wells. Deputy Petroleum Administrator Bruce K. Brown supplied the following break-down of the PAD approvals by the type of project involved:

	Cases Approved	Total Value of Projects
Gas	1,747	$1,349,614,996
Refining	665	1,124,677,502
Supply and transportation	668	727,363,692
Natural gasoline	314	265,095,204
Marketing	99	11,813,651
Production	80	38,396,239
Totals	3,573	$3,516,961,284

Mexico Oil Output Jumps

Latest figures released by Pemex, the Mexican government petroleum monoply, has announced that crude production for 1951 was at a record peak for government operation—78,780,387 bbl. Average production at the close of 1951 was 230,000 bbl a day. Home consumption was 50,550,000 bbl last year, a 52 per cent jump in 6 years.

Mexico had boasted that she would get her nationalized oil industry working on her own—and without the help of a U. S. loan.

Where oil men of the oil producing countries of the world will congregate in 1953 at the thirtieth anniversary of the International Petroleum Exposition in Tulsa, Oklahoma. At the 1948 show, the last held, when this aerial photograph was taken, oil men from 43 countries of the world and 29 states of the union attended.

NTOGA Holds Annual Meet In Wichita Falls, Texas

The North Texas Oil and Gas Association held its 22nd annual meeting in Wichita Falls, Texas, March 29. The more than 1200 oil men gathering in Wichita Falls, for the meeting heard speakers discuss major problems confronting the oil industry.

At the technical session, with W. T. Kendall, presiding, speeches were: "The Use and Advantage of Jet Nozzled Rock Bits" by L. L. Payne, chief engineer, Hughes Tool Company, Houston, Texas.

"Economic Advantages of Unitization" by L. E. Brock, unitization superintendent, Sanolind Oil and Gas, Tulsa.

"History and Development of the South Ward County Water Flooding Projects", G. L. Buckles, consulting engineer, Buckles and Hostetler, Monahans, Texas.

General session, Charles N. Prothro, presiding. "Oil Field Tubular Goods," by R. L. Foree, director of production, Petroleum Administration for Defense.

"How You Can Assist in the Oil Industry's Public Relations," by Don Agnew, district representative, Oil Industry Information Committee, Dallas.

"The Price of Crude Oil," by Harold B. Fell, executive vice president of the Independent Petroleum Association of America.

Annual banquet. M. E. McCullough, presiding. Speakers: General James H. Doolittle, vice president, Shell Oil, New York, General E. O. Thompson, senior member, Texas Railroad Commission, Austin, Texas, "Oil for 1975".

Luncheons. Directors. M. E. McCullough, presiding. Speaker—Olin Culberson, chairman, Texas Railroad Commission. Production Committee and North Texas Petroleum Engineers. W. T. Kendall, president. Speaker—William J. Murray, Texas Railroad Commission.

Tax Committee and North Texas Petroleum Accountants. Lee Erwin, presiding. Speaker—W. H. Garbade, president, Deep Rock Oil Corporation, Tulsa.

Desk and Derrick Club. Evelyn Halverson, presiding. Speaker—Ernestine Adams, managing editor, The Petroleum Engineer, Dallas, Texas.

PAD Export Figures

Below is the PAD summary of U. S. exports of major petroleum products. Figures are in thousands of barrels daily:

Week ending	Avgas*	Motor gasoline	Kerosine	Distillate	Residual	Total
February 29..	65.3	31.7	....	72.0	52.6	221.6
March 7.....	42.2	13.1	29.5	10.3	37.5	132.6
March 14.....	16.3	2.6	16.9	21.1	76.7	133.6
March 21.....	33.1	11.7	10.3	66.3	64.2	185.6

* Avgas is partly estimated and includes all methods of shipment.

Steel Output Cut by Walkout of Steelworkers

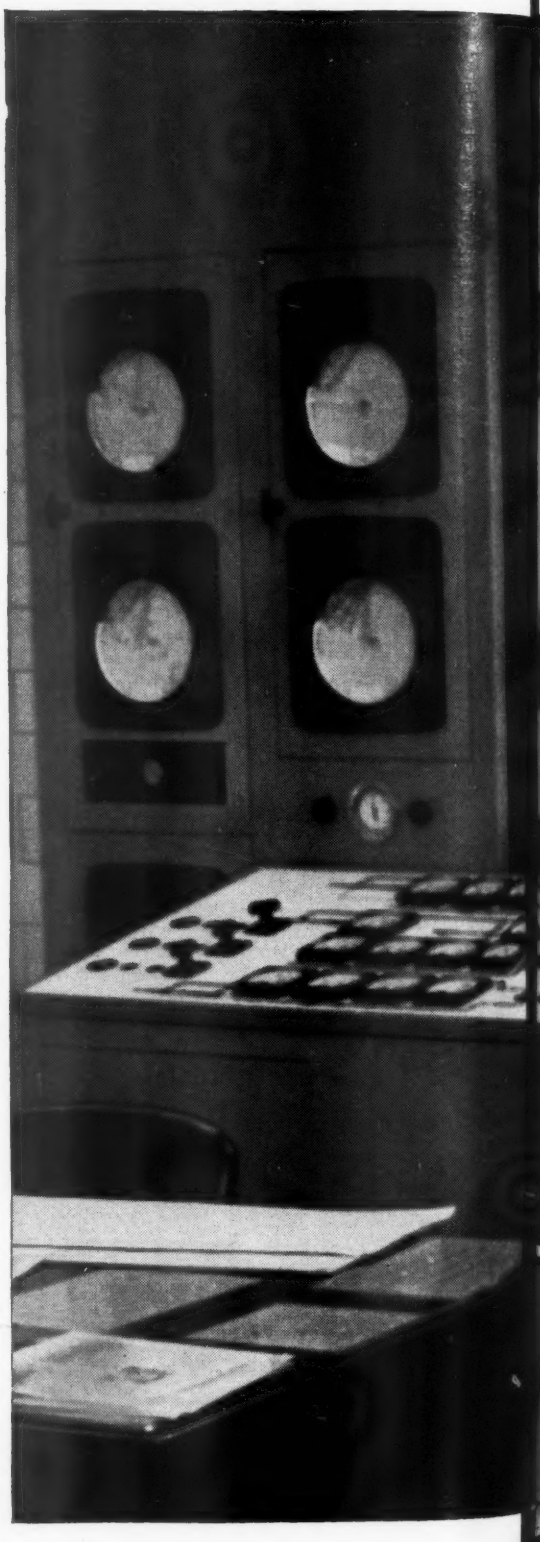
Before seizure of the steel mills by the President, an estimated 1,000,000 to 2,000,000 tons of steel has been lost to the country due to the called strike by the CIO United Steelworkers. Steel furnaces began cooling off a few days before the April 8 strike deadline, and required several days more to be brought up to full production. Many plants lost two or three days because workers were not allowed to go back to work during the confusion brought about by the President's seizure order. Secretary of Commerce Charles Sawyer has told steel workers they can expect a wage increase, which the President will set.

PAD will be given 80,000 tons of carbon structural steel during the third quarter, according to NPA. This will allow for extensive construction in the oil and gas industry in the late summer. An NPA report, however, states that according to supply men drill pipe is in such short supply that many drilling contractors are using pipe worn beyond the safety point. Government representatives pointed out that if present rates of production are maintained, 1952 output of drill pipe will be double the 1950 production. Other present shortages include: Drilling rigs, roller chain used on rigs, and nickel-bearing sucker rods.

At Desk and Derrick Club luncheon, Wichita Falls, Texas, March 29: Jean Zorn, Ward and McCullough; Dorothy Rampy and Virginia Fitzgerald, Fain & McGaha; Ernestine Adams, *The Petroleum Engineer*; Evelyn A. Halverson (club president), Magnolia; Lamont Tofte, Texas Seismograph; Lela Porter, Bridwell Oil; Jane G. Hathaway, Panhandle Producing and Refining.

At NTOGA directors luncheon March 29 were: E. B. Clark, first vice president; Elmer Batsell, PAD, Washington; Gen. E. O. Thompson and Olin Culberson, Texas Railroad Commission; M. E. McCullough, president NTOGA; R. L. Foree, PAD; Don Agnew, API Oil Industry Information Committee, Dallas; and Charles N. Prothro, second vice president NTOGA.

Here's how Power System Planning pays off for Plantation Pipeline



When Plantation's line was first built in 1941, Westinghouse worked with them in planning the electrical control system. So many of the ideas paid off in lower maintenance, system flexibility and reduced power costs that the new expansion program incorporates many of these ideas along with some new ones developed between our engineers and theirs. Here are a few of the outstanding features.

Use little more power despite doubled capacity

The new parallel line doubles system capacity but power requirements have increased only slightly. One important way this was done was by preventing extra charges for peak power loads. When the load reaches the upper limit, a flow-control valve automatically cuts it back.

Highly mechanized system

Another feature was the use of automatic controls wherever possible. As a result, the big expansion increased man power needs very little. For example, if abnormally high pressures or temperatures should develop, special equipment automatically shuts down the pumps or sounds a warning.

Radically new instrumentation system

Westinghouse engineers also helped develop a new instrumentation system for the pumping stations. This system using electrical strain gauges permits the use of standard electrical instruments to show pressure. This eliminates the disadvantages of pressure tubing, with its hazards of high-pressure leaks. It also simplifies instrument mounting and permits a simplified compact control board for system operation. These instruments are also more accurate than conventional gauges.

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This is a good example of the kind of thinking we can apply to *all* petroleum industry projects. When your next job comes up, call in Westinghouse early. Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Penna.

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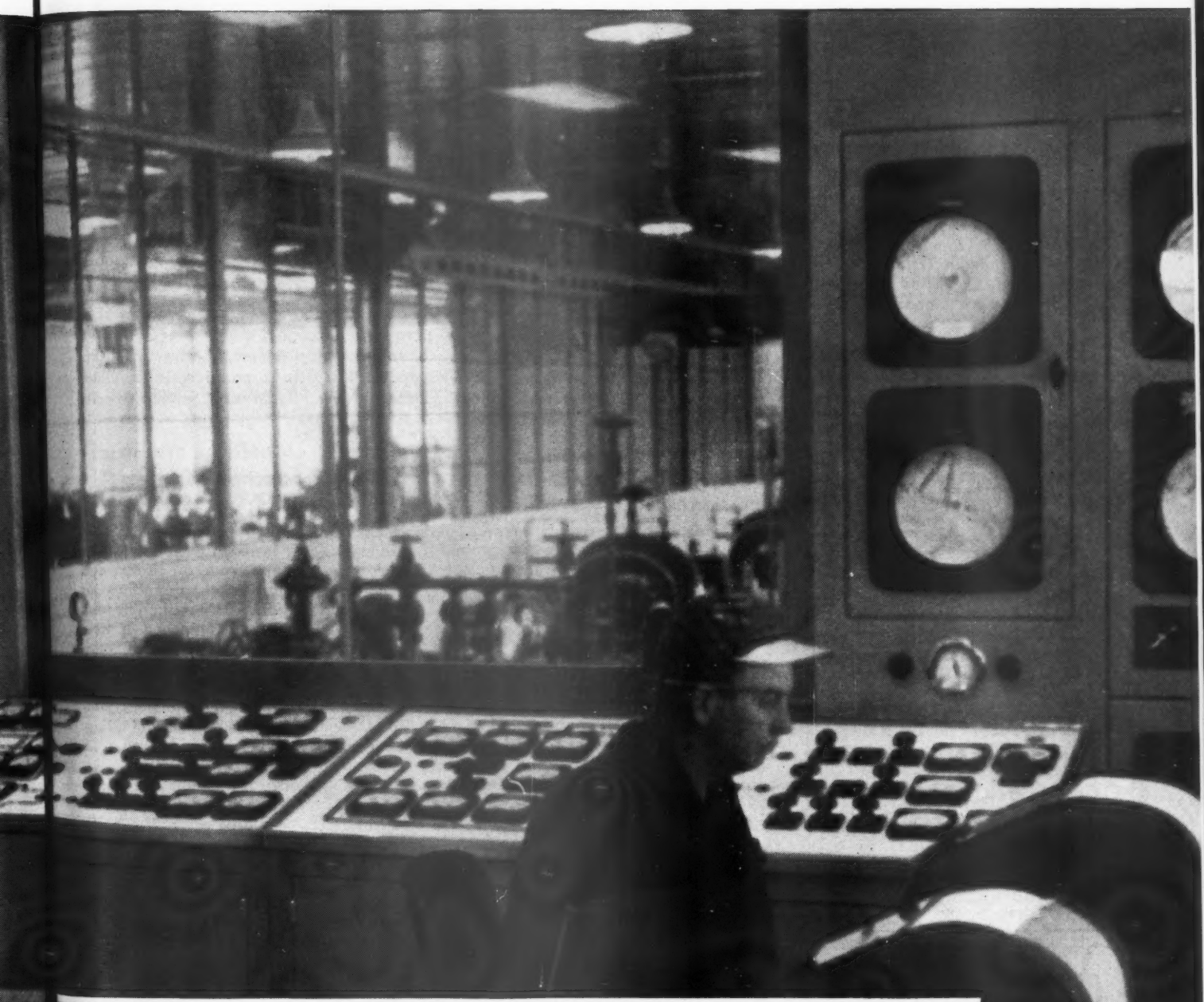
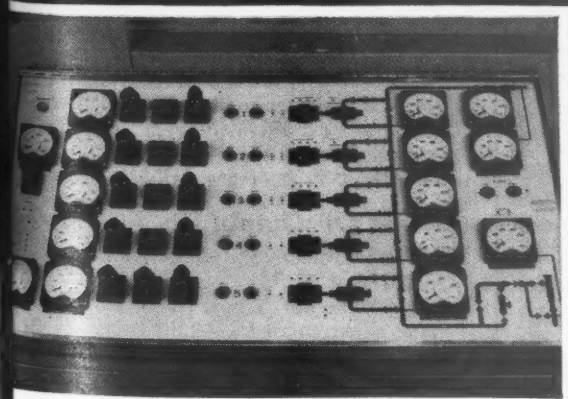
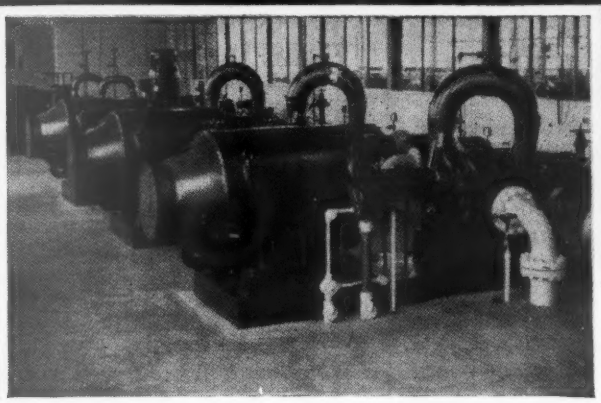




Plantation's highly mechanized pumping stations are operated from these Westinghouse control panels. Electrical pressure gauges were specially developed to permit the use of the simplified flow-control board.



Big explosion-resistant Westinghouse motors drive the pumps on the Plantation Pipeline. These motors were especially designed and built for pipeline duty and they have given outstanding service.

October Oil Output Up U. S. B. of M. Reports

In October, world crude production, 11,927,000 bbl daily, increased 223,000 bbl daily over September, according to a U. S. Bureau of Mines report. This occurred primarily as the result of daily gains of 114,000 bbl in the United States; 78,000 in the Middle East; and an estimated 35,000 bbl in the U. S. S. R. and Eastern Europe. Canada's daily output fell by 7000 bbl. Production rose in the Middle East, principally because of an 83,000-bbl daily gain in Kuwait. Venezuela's daily average production rose by 8000 bbl over September, the report stated.

Western Europe imported 1,289,000 bbl daily of crude in October, an increase of 140,000. Countries where principal daily increases occurred were: United Kingdom, a record 454,000 (388,000 in September); Italy, a record 180,000 (149,000); France, 388,000 (351,000); and Sweden, 38,000 (10,000). The major decline 35,000 bbl daily, occurred in Western Germany.

Exports of crude from Venezuela during October averaged 84,000 bbl daily higher than in September, an increase of 6 per cent. Middle East exports (excluding shipments to Bahrein) attained a record daily average of 1,408,000 bbl compared to 1,310,000 the previous month. During October both Kuwait and Saudi Arabia exported crude at record daily rates of 666,000 and 698,000 bbl respectively. Comparable figures for the two countries in September were 602,000 (Kuwait) and 645,000 (Saudi Arabia).

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Send for list. Can offer Williston Basin minerals for $10 per acre with $1.00 annual rentals. Can sell in minimum tracts of 40 acres. Solicit sales only to those connected with oil or royalty business. References exchanged. Write or call Milburn & Milburn, Sewell Building, Telephone 6-6439, Odessa, Texas.

CHIEF DRAFTSMAN WANTED!

For expanding natural gas transmission company. Must be capable of organizing department and supervising all drafting activities including alignment maps, piping, electrical and architectural layout. Salary commensurate with experience and ability. Please write giving full particulars of education, past experience and recent photograph. All replies will be treated with strict confidence. Box 136, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

SEG Award Winners. Recent award winners at the annual meeting of the Society of Economic Paleontology were: Dr. E. A. Eckhardt, vice president, Gulf Research and Development Company, Pittsburgh, recipient of honorary membership award in SEG; K. C. Heald, vice president, Gulf Oil Corporation, Pittsburgh, Sidney Powers Memorial award winner; Raymond Siever, Illinois State Geological Survey, receiver of AAPG President's Award; and L. Y. Faust, Geophysical Research Corporation, Tulsa, Oklahoma, 1951 best paper award by SEG member. Winning paper was "Seismic Velocity as a Function of Depth and Geologic Time."

Continental Oil Wins NSC Industrial Safety Award

Continental Oil Company has won its thirty-sixth and thirty-seventh annual National Safety Council awards for outstanding industrial safety records, the council has informed J. S. Boylan, director of Continental's safety division.

Both the manufacturing and marketing departments of Continental were judged to have had the best 1951 safety records in the petroleum industry. Conoco's record topped that of 43 other oil firms in manufacturing, and surpassed 24 marketing safety records.

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For middle western natural gas company. Must be qualified to make engineering studies of gas reserves and reservoir performance, interpret and analyse drill stem tests, estimate well production, make pressure surveys and have general knowledge of exploration, drilling and production technique. Salary commensurate with experience and ability. Please write giving full particulars of education, past experience and recent photograph. All replies will be treated with strict confidence. Box 137, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

Creole Production Figures Hit New High in 1951

Creole Petroleum Corporation, a subsidiary of Standard Oil Company (New Jersey) set a new crude oil production record for itself in its operations in Venezuela in 1951. Net production plus purchased royalty oil reached a new figure of 276,679,261 bbl in 1951, or a daily average of 758,025 bbl, compared with 668,184 bbl in 1950. The peak for the year, reached during the week ending December 24, was 801,493 bbl a day. Creole's production amounted to 44.5 per cent of total in Venezuela.

Creole's refineries at Amuay and Caripito processed 46,281,712 bbl of crude oil in 1951, compared with 41,304,916 bbl in 1950.

The company's gas conservation efforts were intensified during the year. A $16,000,000 pressure maintenance plant was designed to inject 130,000,000 cu ft of gas into LL-370 Eocene reservoir in Lake Maracaibo. It is expected that the plant will be completed in about three years and should recover about 150,000,000 bbl of oil for this field and conserve a considerable quantity of gas.

The capacity of the crude stabilization and pressure maintenance plant at Jusepin, Eastern Venezuela, was increased during the year from 10 to 25,000,000 cu ft of gas daily.

Soviet Oil Output Up

The Petroleum Press Service has reported that oil production may reach 420,000,000 bbl a year by 1955. The trade paper carried a detailed review of the Soviet oil industry, stating that all its figures were based on indications given in official Russian announcements. It reckoned, on that basis, that Soviet oil production in 1951 was about 308,000,000 bbl, an increase of 12 per cent and nearly double the 1946 output.

Committee to Iron Out Tidelands Legislation

The Senate and the House of Representatives are holding a committee meeting in an attempt to reconcile the two tidelands bills passed by the Senate and the House.

Latest bill passed by the Senate gives the coastal states title to the oil-laden submerged lands lying off-shore between the low-tide mark and the three-mile limit. The House passed a similar measure last year by a two-to-one majority.

President Truman, however, is expected to veto the bill should the Senate and the House agree on legislation giving the off-shore lands to the states. It is considered doubtful that there are enough votes to override a veto.

The measure passed by the Senate would give the states the right to the land and the revenues from the land, lying between the low water mark and the three-mile unit. This applies to all states except Texas—where a 10½-mile limit was granted. Beyond this, revenues would go to the Federal Government.

Librarians to Meet

The Special Libraries Association holds its annual meeting the week of May 26 at the Statler Hotel, New York. The petroleum section of the science-technology division plans a round-table discussion, May 26, and 27, between industry representatives and librarians, divided according to API subdivisions of production, transportation, refining, marketing, and public relations.

Speakers will include C. L. Thomas, Sun Oil; Thelma Hoffman, Shell Development; F. W. Mann and S. J. Bragg, Continental Oil; Wallace West, API; Clara Miller, Imperial Oil; J. M. Pearson, Sun Oil; G. H. B. Davis, Standard Oil, and others to be announced.

Superior Reported Set To Leave Persian Gulf

Superior Oil Corporation is reportedly planning to stop its exploration program in the Persian Gulf soon.

Majority owner and operator of International Marine Oil Company, which has been doing geophysical work in the offshore waters of Qatar and the Trucial Coast, Superior's withdrawal would leave only one operation in the Middle East not affiliated with the major international oil companies. American Independent Oil Company-Pacific Western Oil Company is the other company, which is exploring the Saudi Arabian-Kuwait Neutral Zone.

Central Mining Corporation of South Africa holds the other interest in International Marine and the two partners are now holding negotiations. According to unofficial reports, a change will result in either or both companies leaving the Persian Gulf. There is also a possibility that Superior may wind up with a minority interest but not as the operating company.

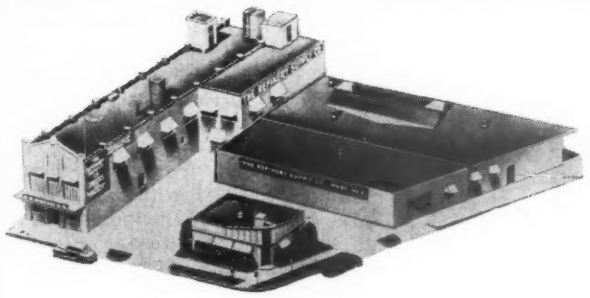
Survey Shows Waste of Engineering Manpower

An estimated 60 per cent of the potential managerial talent of engineers is being lost to industry today, due to poor communications between engineers and the top management of industry. This was disclosed in a nationwide survey of 350 industrial companies employing some 50,000 engineers. A 48-page report on the survey, the result of six months' research by the National Society of Professional Engineers, was released by L. L. Dresser, president of the society.

Dresser, who is also president of Dresser Engineering Company, Tulsa, Oklahoma, said, "Our study shows that 99 per cent of the firms surveyed have engineers in top executive positions, and 92 per cent look to their engineers for future leaders." He added that only 34 per cent of the companies have any program to prepare engineers for future management leadership.

API Safety Awards Given Standard Oil Indiana

Employees of Standard Oil Company (Indiana) won 41 of 156 safety certificates awarded in the oil industry by the American Petroleum Institute in 1951. Of the total 156 certificates, the one for the most man hours worked without disabling injury was won by employees of Standard's Whiting, Indiana, refinery engineering division with a record of 6,000,000 man hours.



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Penn Grade Men Fail to Get Higher Prices on Crude

Pennsylvania Grade crude oil producers appealed to the Office of Price Stabilization for either decontrol of crude prices or an increase of 72 cents a barrel on their product. The appeal was not successful. OPS spokesmen told them that their only hope for obtaining some relief was to get the support of the Petroleum Administration for Defense. Producers did not know, however, if the suggestion were a promise that the increase would be granted should PAD certify its need.

Industry representatives told OPS that production of Pennsylvania crude oil is falling off because rising costs of drilling new wells is making it unprofitable for small producers to continue developing new sources of supply. They urged OPS to raise Pennsylvania crude oil prices to a level that would encourage the increased production from oil wells throughout the Pennsylvania crude oil producing area.

OPS officials agreed that the presentation of the need for higher prices could not be denied as shown by facts laid out by the group, but that under the regulations there was no way in which a better price could be provided on an area-wide basis, although admittedly needed.

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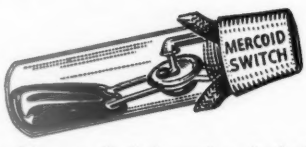

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Oil Industry Faces New Problems, Craig Reports

Announcing that today the petroleum industry is faced with an entirely different problem than it faced even one year ago, Earle M. Craig, president of the National Petroleum Association, told the members assembled at the 49th semi-annual convention in Cleveland, Ohio, "Even though the defense program is still going strong, it appears to have slowed down in some respects. This is affecting several industries, including petroleum. Within the past few weeks several restrictions that hampered our ability to supply the public as well as make necessary expansions to serve increasing demand have been relaxed. The PAD, while not entirely immune from complaints, has administered its controls fairly, and with an effort to preserve the competitive position of the smaller units in the industry.

"This also seems an appropriate time to call attention to the fact that despite the apparent slackening in the inflationary pressures of the defense program, some of the other arms of the Government seem to be eager to increase controls rather than to relax them. There is serious doubt whether there is need for continued price controls The effect in some cases seems to be only to force the industry into a strait jacket preventing normal adjustments. For example, we read that the East Coast is desperately short of bunker fuel, that ships carrying foreign aid (including coal, by the way) are tied up for lack of bunker oil. Yet at the same time in this part of the country refiners are faced with a surplus of residual oil. This is a situation which would normally be adjusted by price changes so that oil would move to where it is needed, probably without any overall increase in cost to the consuming public.

"The constant effort of Government planners to deal with all companies, large and small, in the industry in terms of a national "pattern" represents a real threat to the existence of the smaller companies that must of necessity operate as individuals."

Anglo-Egyptian Halts Drilling in Egypt

Anglo-Egyptian Oilfields, Ltd., Shell Oil Company subsidiary, has stopped drilling operations in Sadr on the Red Sea, where it has "exhausted the possibility of finding any more oil." Work stoppage resulted in the laying-off of 275 workers in that territory.

According to the company the Egyptian mining law contains such harsh restrictions on oil that "not one company has elected to begin exploration operations since the law was passed"

The Egyptian government is considering revision of the law, which provides for 51 per cent or more Egyptian control in oil companies.

Socony-Vacuum Oil Company stopped drilling operations in Egypt in March, laying off 235 workers. Reason was the mining law restrictions.

PERSONALS

L. A. Sunkel has been elected vice president of The Atlantic Refining Company, and appointed general manager of crude oil production for Atlantic. Sunkel, who makes his home in Dallas, Texas, was educated at Trinity University, Waxahachie, Texas. Since 1919, when he joined Atlantic, he has been in the producing end of the business and in Atlantic's producing headquarters in Dallas.

C. B. Truitt

C. B. "Ike" Truitt has been made a member of Hiwan Petroleum Company, Houston, Texas, as vice president and manager of sales. Truitt received his degree in mechanical engineering from the University of Oklahoma in 1931. His operating headquarters will be in Houston.

Dale Nix and **J. C. Stirton** have been elected vice presidents of the Arabian American Oil Company. It was also announced that **E. G. Voss** has been elected treasurer.

Nix will be in charge of technical and supply services. He joined Aramco in 1940 as manager of the producing, pipelines, and transport department. Last year he was made general manager of oil operations. Stirton will be in charge of engineering and construction. He has been associated with the oil industry for 33 years. In 1919 he joined Standard Oil Company (Indiana), in 1920 he transferred to Standard of California, and became chief engineer for Aramco in 1944. Voss began his career as an office boy with the Standard Oil Company of New Jersey in 1934. In 1946 he headed that company's investment and finance division and two years later became assistant treasurer of Aramco and from this position he achieved his present promotion.

Melvin I. Smith and **Sidney M. Foulks** have been awarded 1952 incentive fellowships by Socony-Vacuum Oil Company. Smith works in the Socony-Vacuum technical service department and Foulks in the field research laboratories of Magnolia Petroleum Company. These fellowships are offered to encourage scientific studies by company people and to promote better understanding among members of the teaching profession and industry.

David W. Harris, president and a director of Universal Oil Products Company, Chicago, will deliver the address at the Sixty-Ninth Commencement exercises of Georgia Institute of Technology, June 9, school officials recently announced.

Harris, who is widely known throughout the petroleum industry, is a son of the late Nathaniel E. Harris, a former governor of the State of Georgia, and a founder of Georgia Tech. He was graduated from Georgia Tech in 1912 with an engineering degree. He joined the Denver Gas and Electric Company as an engineer and in 1913 he was made director of the budget and assistant treasurer of Cities Service Company. Successively he became treasurer of Empire Gas and Fuel Company, vice president of Indian Territory Illuminating Oil Company, vice president and general manager of Arkansas Natural Gas Corporation, president of Orange State Oil Company, vice president and director of Cities Service Defense Corporation, and president of Arkansas Natural Gas Corporation and all of its subsidiaries.

In addition to his varied business duties as executive head of Universal, Harris is also active in industry and civic affairs. He is a Councillor of the American Petroleum Institute, and director of Mid-Continent Oil and Gas Association.

E. P. Priebe has joined the Bay Petroleum Corporation of Denver, Colorado, as secretary-treasurer. He was formerly internal auditor Skelly Oil Company, where he had been employed for the last 18 years. He is a graduate of the University of Illinois.

C. F. Wilmsmeir and **E. A. Galvin** have received advancements by Western Gulf Oil Company, subsidiary of Gulf Oil Corporation. Wilmsmeir has been transferred to the general staff as fiscal and economic advisor to vice president R. P. Higgins of Western Gulf. Galvin, formerly technical advisor to vice president Huggins, has been transferred to the company's Paloma unit in Kern County, California, and will serve as general superintendent in charge of the Paloma unit, including the cycling plant and production field.

Wilmsmeir was educated at the University of California and joined Western Gulf in 1938 as a clerk. Galvin received his B.S. degree in petroleum engineering from the University of Southern California in 1938. He joined Western Gulf in 1945.

Leo W. Stach, of Tokyo, Japan, technical consultant for petroleum and natural gas development in the Far East, recently spent a month in Taiwan (Formosa) at the invitation of the Chinese Petroleum Corporation, and under the auspices of the Mutual Security Agency Mission to China. The purpose of his visit was to evaluate the potentialities for the development of the oil and natural gas resources of that territory.

J. E. Toussaint

J. E. Toussaint was named a vice president of Standard Oil Company of California by the board of trustees. A veteran California oil man, Toussaint has been general manager of the company's producing department for the past seven years. His history with Standard Oil of California, however, goes back 30 years to his graduation from the University of California in 1922. Toussaint joined California Standard as a construction engineer in the company's Richmond refinery, and held a number of engineering jobs before turning to oil field production work.

Toussaint was named general manager of operations for California Standard's producing department in 1941, and was selected to head that department in 1945.

John C. Sample will rejoin the General Petroleum Corporation after an absence of three years, according to Robert L. Minckler, the company's president. Minckler revealed that Sample has been appointed assistant to the president. Sample returns to General Petroleum from the Standard-Vacuum Oil Company in New York where he has represented that organization in South Africa, Australia, New Zealand, and Japan. He had been a director of Socony-Vacuum since joining the company in 1949.

Dr. Harry H. Power, University of Texas petroleum engineering professor, is the new chairman of the American Institute of Mining and Metallurgical Engineers' Mineral Industries Education Division.

During 1952-53, the division will seek ways to fill the unprecedented demand for mineral industries engineers and to push research toward better utilization of the nation's mineral supplies, Dr. Power said.

J. I. Laudermilk, Socony-Vacuum Oil Company, Inc., is on a trip through the petroleum industry of the South and Southwest, including Louisiana, Oklahoma, Texas, and several other states. He addressed technical students meetings at leading educational institutions. At the University of Oklahoma he was made an honorary member of Pi Epsilon Tau, national petroleum engineering fraternity, and was the speaker at the initiation banquet on March 15 at the Norman Country Club.

Personals

John Dawson Coleman, executive of the Frigidaire division of General Motors Corporation, has been elected president of the National Society of Professional Engineers. He will assume office on July 1, 1952, and serve for one year.

A graduate in chemical engineering from the University of West Virginia, Coleman now supervises the use of all material going into the manufacturing process at Frigidaire's vast Dayton plant.

Six vice presidents were elected—each to represent various areas of the United States. They are:

Clarence T. Shoch, manager of industrial sales, Pennsylvania Power and Light Company, northeastern area.

Nathan W. Dougherty, dean of the school of engineering, the University of Tennessee, Nashville, Tennessee, southeastern area.

Edwin W. Seeger, vice president in charge of development of Cutler-Hammer of Milwaukee, central area.

William D. Williams of Phoenix, Arizona, a sanitary engineer, with the engineering firm of Headman, Ferguson, and Carollo, western area.

T. Carr Forrest of Dallas, Texas, consulting engineer, southwestern area.

Christopher Y. Thomas, vice president of the Spencer Chemical Company of Pittsburg, Kansas, north central area.

Professor Russell B. Allen, College Park, Maryland, head of the civil engineering department of the University of Maryland, has been elected treasurer.

Glenn W. Clark, newly elected president of the Cities Service Gas Company, has been named a member of the Gas Industry Advisory Council by Secretary of the Interior Oscar L. Chapman. On the Council, Clark succeeds **S. B. Irelan,** whom he also succeeded as president of Cities Service Gas. Irelan has been elected president of Cities Service Oil Company (Delaware). The Gas Industry Advisory Council advises and counsels the Secretary of the Interior and PAD on gas matters relating to defense.

Robert M. Lee

Robert M. Lee has been appointed personnel and industrial relations manager for Shell Oil Company in Casper, Wyoming, according to announcement by J. E. Clark, Rocky Mountain division manager.

Lee graduated from Pomona College and first joined Shell in 1938 as a roustabout in Long Beach. Later he was transferred into the personnel department and worked in the Los Angeles and Ventura offices.

Following a year in the New York personnel department, Lee became personnel supervisor in the Houston office, a position he has held until his recent assignment in the Rocky Mountain division.

J. M. Pritchard, former president, has been named chairman of the Board, of McColl-Frontenac Oil Company, Ltd. He succeeds **A. A. Magee,** who now becomes chairman of the executive committee. **T. C. Twyman** has been elected president and chief executive officer of the company. **G. R. Taylor** succeeds Twyman as executive vice president.

C. C. Dunn was re-elected vice president in charge of sales. **A. G. Farquharson** was elected vice president in charge of refining, and **T. V. Anderson,** former treasurer and comptroller, is now vice president and treasurer. **Fred Hunt** was re-elected secretary.

Dr. Judson Swearingen, nationally known for his work in uranium plant construction during the war, has been named director of petroleum technology for Southwest Research Institute, Dr. Harold Vagtborg, Institute president, announced. A veteran member of the staff of the internationally known scientific research organization, Dr. Swearingen has been the institute's chairman of chemical engineering and one of its key scientists and engineers almost since it was founded in September, 1947.

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DEATHS

Max Steineke, chief geological consultant to Arabian American Oil Company, San Francisco, died April 16 in Los Altos, California. Steineke was awarded the Sidney Powers Memorial medal, highest honor in petroleum geology, last year by the American Association of Petroleum Geologists. The award was given in recognition of his work in discovering and developing vast oil resources in Saudi Arabia.

Jonkheer Ir. O. C. A. van Lidth de Jeude, Dutch engineer who was president of the Third World Petroleum Congress, held at the Hague last June died February 1. A great deal of the success of the Congress was due to his enthusiasm and work. He became ill at the inauguration ceremony and was unable to attend part of the Congress. He had held ministerial offices and was the recipient of some of the highest honors that the Netherlands can bestow.

Jake Lieberman, oil lease broker, who helped develop the Stroud field died April 11 in Salt Lake City, Utah. A native of Russia, Lieberman came to the United States when he was a boy and lived in New Hampshire until moving to Tulsa, Oklahoma, in 1918. He obtained a number of blocks and leases throughout the states, and became one of the oil men who brought in the original discovery well at Stroud, Oklahoma.

Joe Baker Tims, pipe line superintendent for Lion Oil Company, died April 9 at his home in El Dorado, Arkansas. He had been employed by Lion Oil Company for the past 29 years. Tims was a member of the Methodist Church; the El Dorado Lodge No. 13 of the F. and A. M., and a veteran of World War I.

Oscar L. Garrett, co-owner of Petroleum Tool Company of Odessa, Texas, died at Mayo Clinic, Rochester, Minnesota, on March 22. He began as a cable tool dresser during the Tampico boom and later moved to Venezuela, where he worked up to personnel manager of a major American company. Returning to Houston in 1937, he was active in drilling and supply circles, moving to Odessa in 1947. In 1950 he and D. P. Blaker organized Petroleum Tool Company.

Francis Fargo Gregory, merchandising coordinator of A. O. Smith Corporation, died March 8 following an operation. He had been with A. O. Smith since 1944, serving first as sales promotion manager, then public relations director and finally as merchandising coordinator.

Arnold C. Hackstaff, manager of the Denver district sales office for The Youngstown Sheet and Tube Company, died at Denver, Colorado, March 25, an hour after he was stricken with a cerebral hemorrhage. Hackstaff joined Youngstown in 1919, and had been manager of the Denver office since 1928.

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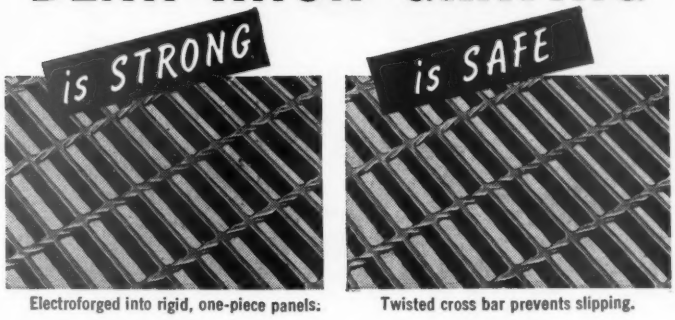

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vent of the area meter handbook and well-established primary element specifications, the initial sizing and manufacture of the area type meter is as well defined as the more popular orifice practice. (Fig. 4) One or two "Flowrator meter specialists" in each instrument engineering group or maintenance shop will certainly help speed the maximum utilization of the area meter principle. Until such time, the area meter may well continue to be a stepchild assigned to clean-up jobs on those applications where all other more traditional methods have proved inadequate.

It is believed that a fair review of the associated comparisons of area meters and head meters can logically permit us to say that the variable area meter will encroach more and more as time goes on in those measurement applications where the following requirements exist:

Wide range of flow rate.

Good linearity (for flexible proportioning of two or more flows or simple correlation of a flow signal with other linear response variable).

Corrosion resistance.

High viscosity.

Freezing or congealing (strong chemicals, waxes, asphalts).

LPG measurement (gasification in lead lines).

Slurries or streams with suspended solids.

Low pressure drop.

In addition, there should be a continuing use of variable area meters for all measurement of low flows of whatever fluid or whatever requirement if present claims for flexibility and convenience of use are found to be true and accepted by refinery instrument engineers. Coefficient shifts of small orifice meters continue to make the area meter a more dependable instrument for low flow rate work. Excellent repeatability of low flow rates of jet fuel for engine test stand work permits ½ per cent guaranteed maximum deviation from absolute accuracy from maximum to one-fifth of full scale, and checks of normal production run test meters performed at the Bureau of Standards show an average deviation in the order of 0.15 per cent of rate across the entire measurement scale.

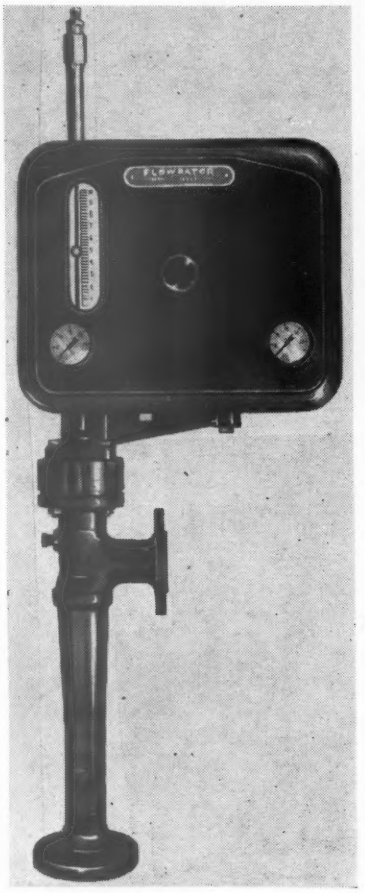

FIG. 2. All metal Flowrator meter Fig. 52 with Magnabond pneumatic transmitter. The Magnabond coupling permits frictionless transfer of float position to secondary instrument mechanisms without the use of a stuffing box. Standard in the V/A Cell, Cable and Drum Levelimeter, and Magnasight.

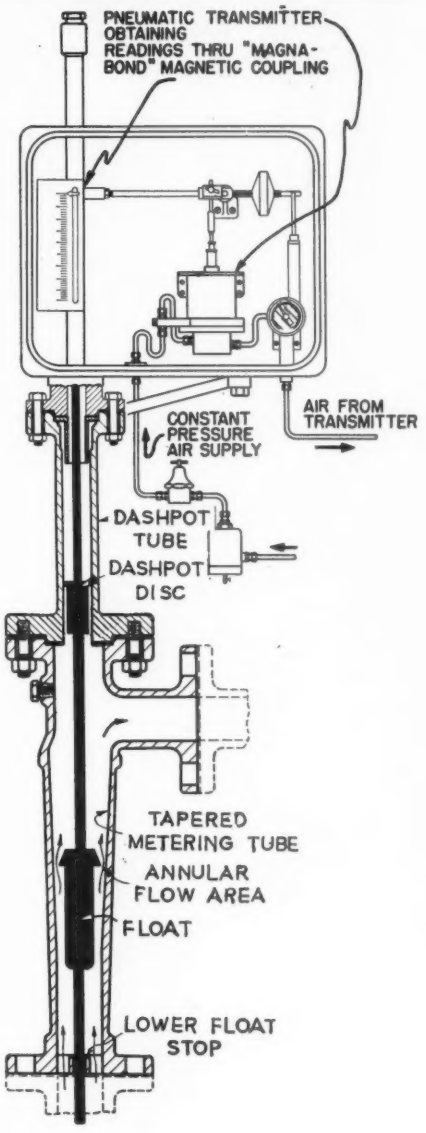

FIG. 3. Cross-section of the Fig. 52 Flowrator meter. This cut shows the dashpot extension between meter and transmitter to stabilize the float for measurement of pulsating flows. The same housing permits float weight addition to increase the capacity of an instrument.

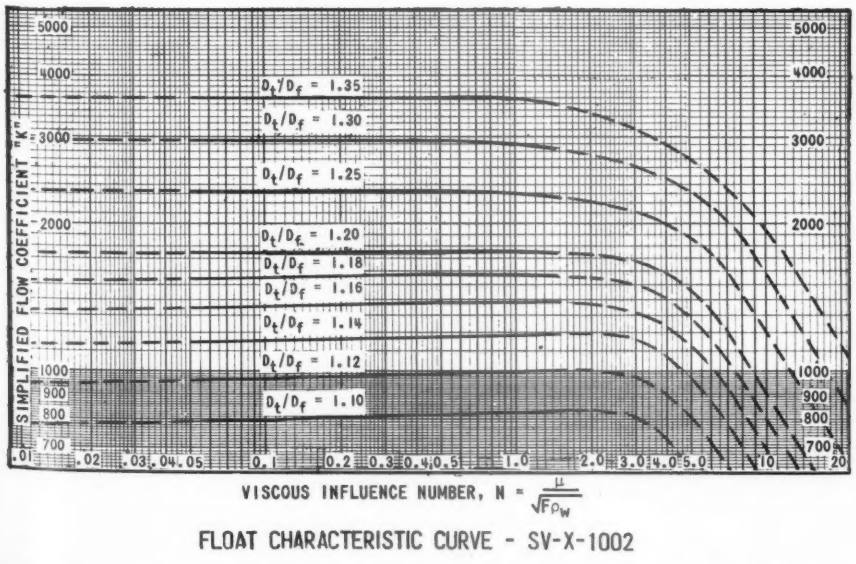

FIG. 4. Section of predictability curve as published in the area meter handbook. Permits determination of actual flow capacity at any float position by solution of the absolute equation "$W = KD_t\sqrt{F\rho w}$" at any influence number (similar to Reynolds number).

V/A Cell and Oriflowrator Kinetic Manometers

There are adaptations of the area type meter to viscosity work that should be given separate attention as a field of measurement separate to flow rate is involved, and this article will not cover the area meter as a viscosity instrument.

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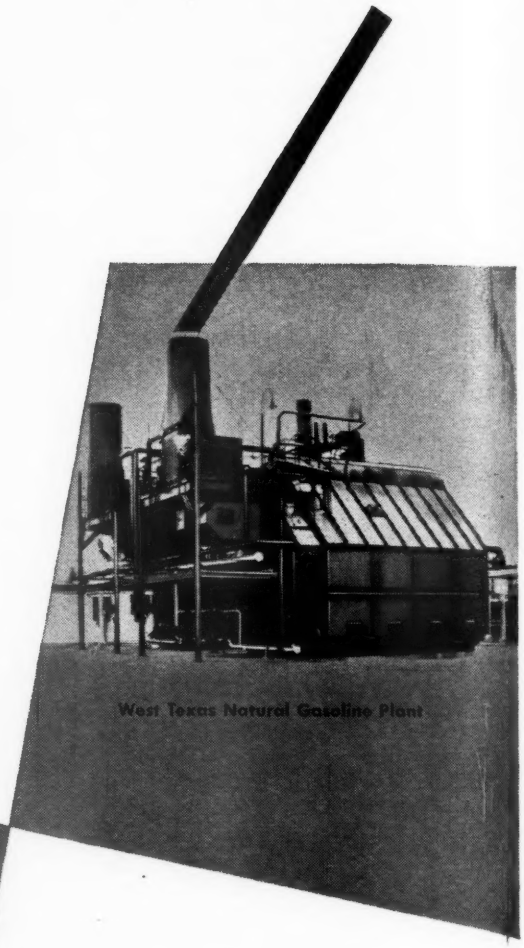
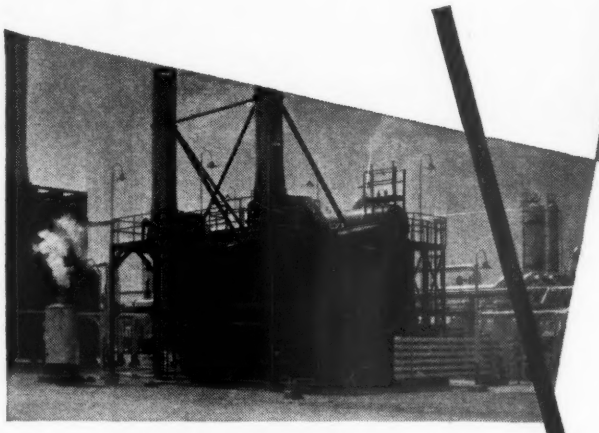
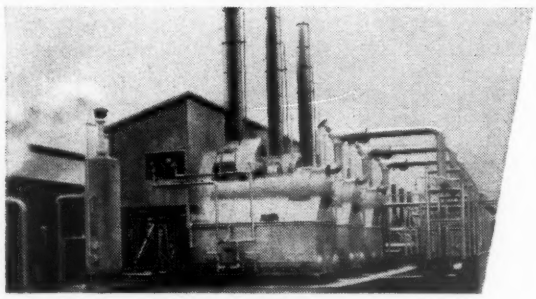


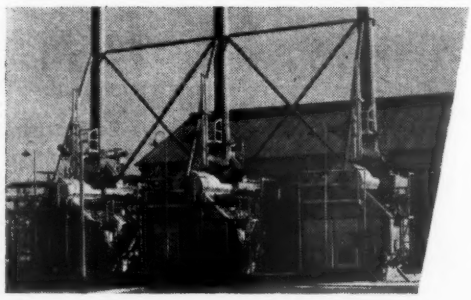
West Texas Natural Gasoline Plant



Central Texas Natural Gasoline Plant



▲ Louisiana Refinery



▼ Indiana Installation

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136

To obtain more information on products advertised see page E-49

The area meter, however, has been ingeniously applied to differential measurement across an orifice. The Flowrator meter measures the by-pass flow rate created by the differential across the orifice rather than the static differential itself, and the unit is very properly called a "kinetic" or flowing manometer. As main line and by-pass flow rate are proportional in the first power, the kinetic manometer has a linear scale in contrast to the square root scale of the static manometer. It is one of the first radical developments in flow rate measurement as the introduction of the area type meter for general industrial work. (Figs. 5 and 6.)

The Oriflowrator indicator and the V/A cell pneumatic transmitter permit the advantages of the orifice primary to be retained while they contribute the desirable features of wide range and linear scale. Previously, these advantages had only been obtained by special adaptations of the manometer element that included no change of the basic principle. Kinetic manometers are already finding widespread use in many petroleum applications for general measurement as they are applicable to any orifice measurement job wherein a special operating problem has not dictated the use of the area type meter—as in the applications listed at the conclusion of this article.

Installations involving orifice-V/A cell units or orifice-V/A cell combinations with Flowrator meter transmitters are handling gasoline-inhibitor blending, fuel oil-additive blending, and particularly feed water-caustic-phosphate-sulfite blending in large boiler water treatment plants. The variations in water demand and hardness make wide range meters a necessity for water treatment reagent proportioning.

FIG. 5. Schematic drawing demonstrating operating principle of the kinetic manometer and showing operating parts and simple construction of V/A cell transmitter.

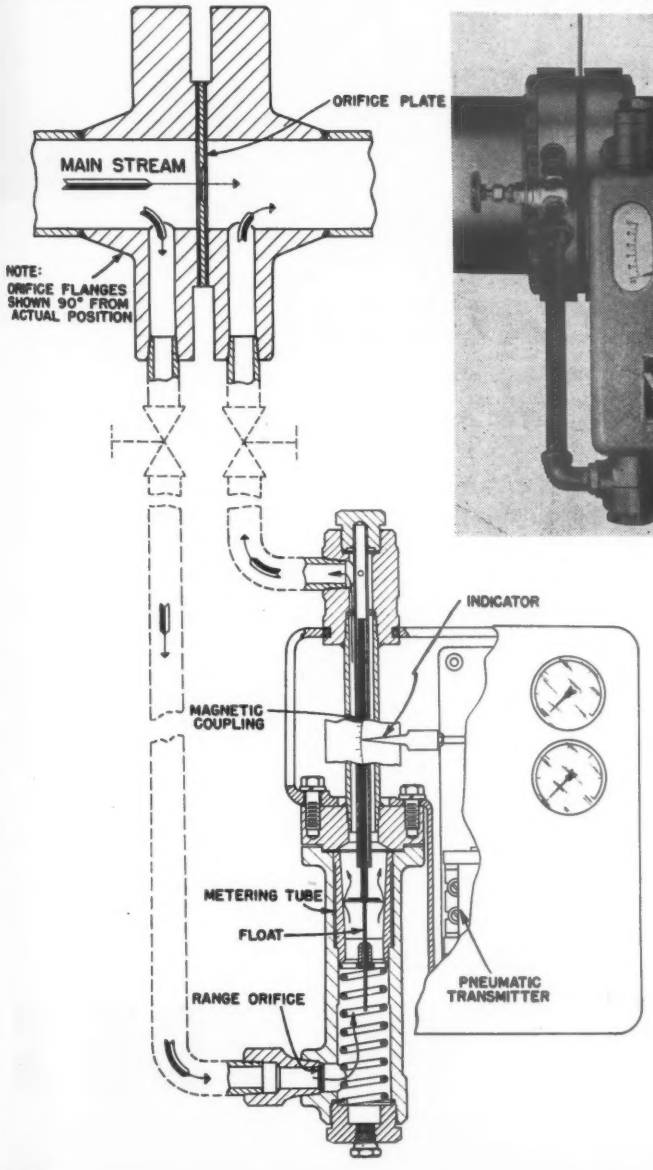
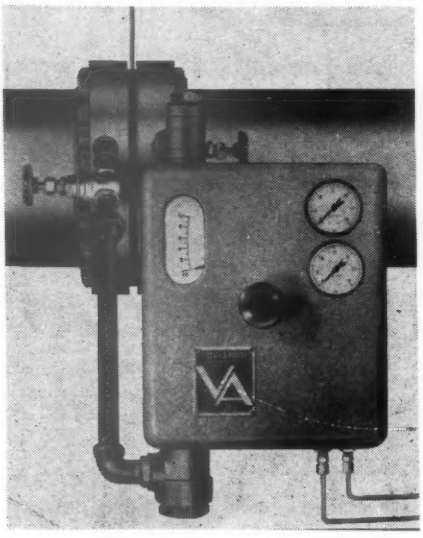


FIG. 6. V/A cell kinetic manometer pneumatic transmitter. New principle permits linear scale, wide range measurement with orifice or other differential creating primaries.



Flowrator Meters in Crude Oil Service

In the Ohio-Pennsylvania field, Flowrator meters are utilized to measure input rate to central storage, and dependable measurement despite pulsative delivery by reciprocating pumps, plus the need for wide range measurement due to delivery from one or more wells, has indicated the use of the area type meter. In addition, viscosity immunity at operating temperatures to prevent significant measuring errors from seasonal viscosity changes was mandatory. A heavy float with high viscosity immunity ceiling handled this problem.

A totalizing Flowrator meter on the receipt of crude from tankers has been carefully tested and approved for Customs duty determinations at one port.

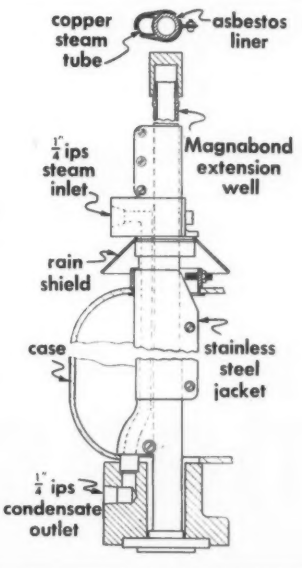
Pipe line and production companies inject ammonia at rates established by Flowrator meters into vapor spaces above sour crude oil in storage tanks to reduce corrosion.

Natural Gasoline Plants

In the Gulf Coast area, numerous installations of Flowrator meters are made on reagents (amine solution, dilute caustic, et cetera) to gas scrubbers, while air and gasoline to gasoline treaters are also conveniently handled. The most distinctive application of the area type meter in this operation, however, is for blending butane and propane to yield LPG at known and constant vapor pressure. Here the ability of the area meter to handle volatile hydrocarbons and its value as a linear primary element in wide range flexible proportioning systems stands out.

The wide range of the area meter also makes it ideal for cooling water service on make-up, return from load, and delivery to the plant from the cooling tower. Independence from the requirement for long metering runs permits a compact, economical installation.

FIG. 7. Steam-jacketed Magnabond extension for use with high pour point streams. New design permits standard Magnabond follower gap and moderate operating temperature in Magnabond instrument case.



One of the ten gauges used on the panel above . . . specially designed for Emsco

VITAL JOB FOR GAUGES

. . . only the best can measure up to it

That panel board is the nerve center of the rig . . . and those ten pressure gauges actually guide every move of the operator. This is no place to take chances on instruments of questionable quality; so the manufacturer of the rig—Emsco Derrick & Equipment Co. —has chosen the gauges that have proved worthy of this kind of trust . . . Marsh Gauges.

The choice of Marsh instruments by manufacturers of highest quality equipment in which pressure indication plays a vital part, is a familiar story. And the reason for this preference is equally familiar to everyone who has rubbed elbows with those dependable Marsh Gauges that are doing their job so supremely well wherever oil flows.

Marsh Gauges have been accorded top preference in the petroleum industry because they have set new standards all their own. Ask your supply house for facts or write for bulletins.

MARSH INSTRUMENT CO. *Sales affiliate of Jas. P. Marsh Corporation* **Dept. M, Skokie, Ill.**
HOUSTON BRANCH PLANT: 1121 Rothwell St., Sect. 15, Houston, Texas

MARSH GAUGES

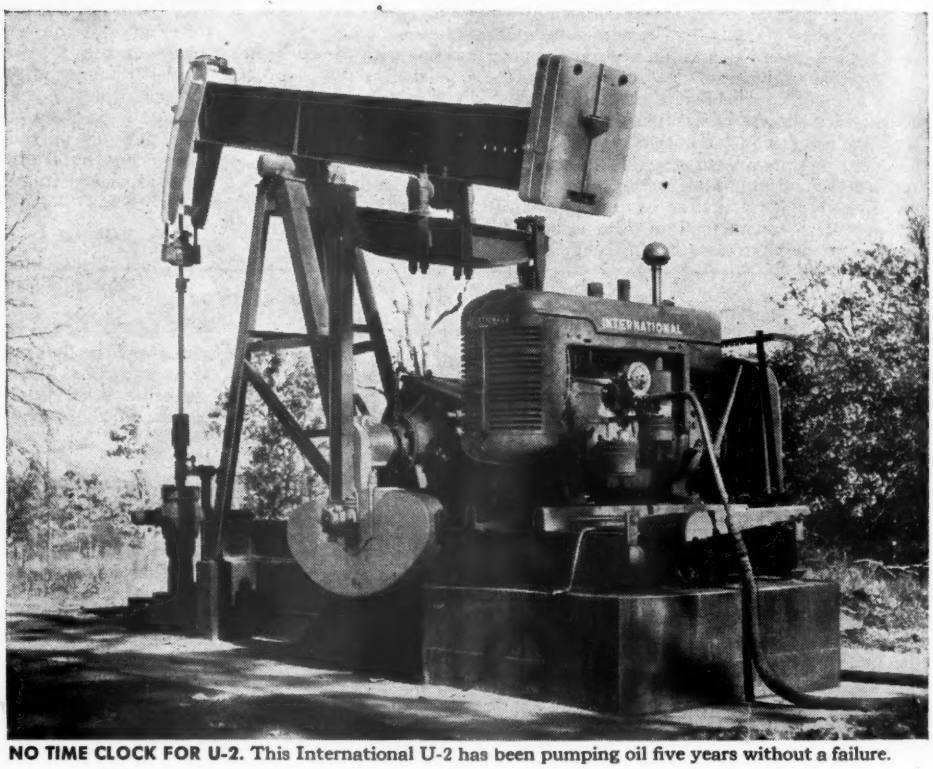
To obtain more information on products advertised see page E-49

Comparison of the Operating Characteristics of Variable Area Meters (Flowrator Meters) and Variable Head Meters (Orifice Meters) with Static Manometers

VARIABLE AREA METER	VARIABLE HEAD METER
SCALE LINEARITY	
"Q" is proportional to "A" in the first power. That is to say, the relationship is linear. "A" is in turn proportional to metering tube ID squared (at the elevation of the float metering edge) minus the float OD squared. Plotting float travel versus "Q" gives almost a straight line. (This slight curvature is rapidly corrected in either the transmitter or the remote exhibiting instrument.) Flow ranges of 10 to 1 or greater are readily handled.	Since "Q" is proportional to the square root of "h", the capacity scale is quadratic with intervals between graduations, representing a given flow increment, becoming ever smaller at the low capacities. Thus the satisfactory range of measurement of the variable head meter (without altering any of its components) is limited to approximately 3½ to 1. By giving the manometer elements a special shape, the scale increments may be made uniform. However, the design principle is not altered, and this method magnifies low differential pressures with consequent uncertainty of performance.
FLEXIBILITY	
The variable area meter has lagged behind the variable head meter as to flexibility where it is desired to move flow meters about from service to service as conditions dictate or where the capacity range of individual meters is to be altered even though they are not moved to a different fluid stream. However, with the introduction of uniform float travel (regardless of size of the meter or capacity selected); with the introduction of percentage scales; with the use of predictable performance floats and tabulations of dimensions and other physical characteristics of floats; the plant instrument engineer is put in a position to alter floats and reapply variable area meters to different flow streams with the same confidence that he has in the past altered sharp edged orifice plates, manometer ranges, or relocated variable head flow meters onto fluid streams of different characteristics.	Flexibility, which the sharp edged orifice plate variable head meter permits in respect to altering capacities and shifting to different flow streams, has been one of its outstanding advantages ever since thorough test programs were carried out by the ASME, AGA, in the U. S., and the International Federation of National Standardizing Associations (ISA) in Europe. This standardization of designs of orifice plates, locations of taps and methods of attaching them, upstream and downstream piping limits, and the plotting of reliable graphs showing flow coefficient "C" versus Reynolds number has permitted orifice meters to be readily moved from one system to another.
PRESSURE DROP	
Since "h" is a constant in any one instrument, it can be determined by the weight of the float, and since the value of "h" may be pre-selected by suitable selection of float weight and diameter, the metering pressure drop is both constant over the entire range of the meter and can be made as low as desired. (Metering pressure drop as low as 0.1 in. of water has been obtained with specially fabricated floats.)	Since "h" is the variable and since its magnitude varies as the square of the flow rate, the pressure loss increases rapidly as flow rate increases. Minimum design pressure loss is limited by the pressure differential which will create a significant deflection of the manometer measuring device.
COMPLEXITY OF METERING COMPONENTS	
The metering float serves a triple purpose: the flow obstruction, the flow response device, and the reading indicator. Thus no external devices are required where direct indication alone is desired. Simple transmitters of magnetic and electromagnetic types are attached to the float without altering its fundamental simplicity.	With "h" the variable to be ascertained, it is necessary to provide not only the flow restriction itself, but some sort of external manometer chamber to which two pressure lines may be brought from opposite sides of the restriction and in which some element sensitive to pressure differences such as mercury (or other liquids), metallic bellows or diaphragms must be employed. Condensable vapors, corrosive fluids, and fluids that crystallize or congeal all require additional complexities in external metering components.
LARGE FLOW MEASUREMENT	
While there is no theoretical limit to the size in which the variable area meter may be constructed, the bulk and weight will increase as the square of the pipe diameter. Therefore, costs, weight, and handling problems become considerations when variable area meters are used for large pipe sizes.	As pipe size increases, all elements of variable head meters remain the same except the restriction inserted in the main line. If this restriction is of the commonly used flat plate orifice design, the extra material required for large diameter installations is not significant and no difficult machining problem is encountered. Therefore, neither weight nor cost increase substantially.
SMALL FLOW MEASUREMENT	
Variable area meters are particularly suitable for small flows and have been used to accurately measure less than 0.1 cc/min. of liquid and 1.0 cc/min. of gas.	The value of flow coefficient "C" tends to become unstable and difficult to predict in pipe sizes below 2 in., and accuracy of measurement becomes steadily more unreliable as pipe size and capacity are reduced.
EFFECT OF DIRT—EASE OF MAINTENANCE	
Due to the annular flow passage arrangement, the variable area meter tends to be self-cleaning. A scouring action of the fluid flow against both the float and the tube wall tends to prevent adhesion of foreign matter. A large obstruction may lodge under the float, but the float can rise beyond the top of the metering tube, discharge the obstruction, and fall back into its proper position. Where pyrex tube meters are used, visual inspection is effortlessly available.	Foreign matter frequently accumulates in the relatively stagnant pockets formed by the restricting device. Dirt, gas bubbles (in the case of liquid measurement), liquid drops (in the case of gas measurement), may accumulate in the lead lines of manometers and visual inspection is not possible, so disassembly is required to determine if cleaning is necessary.

"There Just Isn't Any Upkeep"

Says Superintendent Carl Young of the L. B. Jackson Company, Tulsa



NO TIME CLOCK FOR U-2. This International U-2 has been pumping oil five years without a failure.

Four International engines installed on the Brown Lease, Creek County, Oklahoma, five years ago are still pumping oil daily and have never had a mechanical failure.

"These International U-2s are wonders to operate. There just isn't any upkeep," Superintendent Carl Young points out with pride.

And they do a good pumping job, too. That's why Carl's so strong for International U-2s, why he now has forty of them pumping for him on various leases.

Get the facts and figures on how International power can perform for you. See your International Industrial Distributor, Power Unit Dealer or oil field supply house.

INTERNATIONAL HARVESTER COMPANY, CHICAGO 1, ILL.

INTERNATIONAL INTERNATIONAL HARVESTER **POWER THAT PAYS**

COMPARISON OF THE OPERATING CHARACTERISTICS OF VARIABLE AREA METERS AND VARIABLE HEAD METERS—Continued

VARIABLE AREA METER	*VARIABLE HEAD METER*
PULSATING FLOW	
Under the ideal conditions that the oscillations of the float correspond in amplitude exactly to the amplitude of flow pulsation, then the average reading will be the correct reading. However, in a pulsating flow stream, if the float of the variable area meter is provided with a dashpot so as to almost completely dampen out the pulsations, the readings obtained will be erroneous to exactly the same extent as the readings of the variable head flow meter in that the flow readings obtained by taking the linear average of the pulsations will be the root mean square of the actual flow.	Variable head meters used in a pulsating fluid stream will tend to read high, for the square root of the average differential (determined in a dampened manometer) must differ from the desired average square root which an instrument cannot determine.
APPROACH FACTOR	
The float of the variable area meter acts as a series of impact tubes, that is, like pitot tubes. Thus it is sensitive to and detects not only that velocity which is added to the fluid stream at the restriction, but also the velocity of the approaching fluid stream. Therefore, no approach factor correction is needed in making calculations for individual variable area flow meters.	The manometers of the variable head flow meters are sensitive only to the additional velocity which is created at the restriction except in the case where a pitot impact tube is substituted for the more common orifice plate restriction. Therefore, calculations of ordinary variable head flow meters must include a factor by means of which the velocity of the approaching stream is added to the velocity generated at the restriction to obtain total velocity.
EFFECT OF UPSTREAM PIPE	
The combination of tapered tube and float obstruction acts as a flow distributor to provide relatively uniform velocity to all portions of the annular orifice. Thus the effects of upstream elbows, valves, and other bends are mitigated to such an extent that most variable area flow meter measurement is independent of upstream piping arrangements.	Considerable lengths of straight pipe must be allowed upstream (and also to a lesser extent, downstream) or straightening vanes must be installed to provide a uniform flow pattern for reproducible flow measurement. The manometer taps must be accurately located, carefully made, and smoothly finished.
ACCURACY	
Accuracy guarantees for variable area flow meters are overall guarantees and represent what an engineer would expect them to mean: The degree of accuracy with which the final exhibiting device will reflect the actual flow rate in the pipe line. Certifications as to the accuracy of individual meters are frequently issued, and these state the accuracy at all portions of the scale and may be expressed in percentage of instantaneous flow rate rather than of maximum flow regardless of the fraction of maximum flow which is actually being metered.	The head type meter involves so many elements—most of which are not in the hands of the manufacturer because they are installation conditions—that accuracy guarantees are often meaningless except concerning manometer differential accuracy. Calibrated metering runs including orifice, flanges, and proper taps, with necessary upstream and downstream piping can be provided, but—except in extremely small sizes—these are not economical. It is conceded that orifice practice can be careful enough to permit orifice meters to provide accuracy subject to the deviations listed for published coefficients with minimum allowance for carelessness or error in installation.

Refining

Many refineries are using Series 700 glass tube meters on anhydrous ammonia in the liquid or gaseous phase to fractionating tower vapor line to inhibit corrosion when running sour crudes.

Tower bottoms and tar at 600-700 F are being handled at many refineries. A simple steam-jacketed extension for the popular Magnabond recorder or transmitter maintains the heavy residuum above its pour point. (Fig. 7) Incidentally, a Canadian refinery purchased a large number of area meter transmitters having jacketed extensions for all heavy ends and chemical solutions to assure continuous operation during the winter period. This entirely eliminates the problem of freeze-ups of water in external lead lines of manometer systems.

This same refinery has the first large installation of area meters on the perpetually troublesome catalyst slurry (liquid) lines at the cat cracker. Hardened 440 stainless steel metering edges show no erosion after one year, and another refinery of the same company is considering conversion to area meters on this service.

A particularly successful installation at a Gulf Coast refinery covers the measurement of a side stream cut with extremely low pressure drop and wide flow range caused by variation in feed stocks. A Midwestern refinery has a low pressure drop meter on unstabilized gasoline, metering satisfactorily very close to equilibrium conditions without flashing.

The relatively low flow rates of high viscosity Bunker fuels to furnaces are satisfactorily metered with Flowrator meters at many refineries, and waste gas or natural gas for the same application can give wide rangeability requirements that also require the use of the Flowrator meter.

Gasoline inhibitor ratio control is another popular requirement for Flowrator meter blending, and an entire pipe line gasoline blending system involving nine elements is operating at the Shell-Montreal refinery (*The Petroleum Engineer*, September, 1951). (Fig. 1) Rangeability and accuracy were requisites on this installation. Incidentally, these instruments were precisely calibrated in the presence of the customer's project engineer in our fluids engineering lab.

The critical problem of measuring streams satisfactorily in an HF alkylation unit has been overcome through the use of Flowrator meters, and a large installation at a Midwestern refinery has completed approximately a year of service without downtime. Many other installations exist, and sulfuric acid alkylation streams, of course, are handled equally well with the area type meter. These are typical corrosive, solids-bearing streams in the refinery where the Flowrator meter approach has solved traditional problems.

Many refineries have made the measurement of alkylation spent acid a guinea pig, and good performance on this nasty service has been obtained. Slop oil skimmed from separators is another in this category.

Acid Plants

Quite a few refineries operate their own sulfuric acid plants and—as is the custom in many process plants supplying sulfuric acid—the measurement of molten sulfur for control purposes is a usual entree into the process.

Spent acid measurement and extract-acid measurement for by-products operation have provided spectacular relief from service problems when other types of flow rate measurement had been

LAUGH with BARNEY

The big transport, loaded with passengers, was flying over a state hospital for the insane. All at once the pilot burst out in loud laughter. A passenger inquired: "What's the joke?" "I was just thinking," replied the pilot, "how bothered they will be at the hospital when they find out I've escaped."

* * *

Wife: Doctor, I wish you would see my husband; he blows smoke rings from his nose and I'm terribly worried.

Doctor: Well, that is a bit unusual, but nothing to worry about. Many smokers blow smoke rings by the hour.

Wife: I know, Doctor, but my husband doesn't smoke.

* * *

It is hard to realize that this country was founded partly to avoid taxation.

* * *

Mrs. Mandy Johnson, surrounded by her brood of thirteen pickaninnies, was talking to the spinster settlement worker. "Yes Mam, birth control am all right for youall, but me, I'm married and don't need it."

* * *

Two young women were visiting Rockefeller Center, in New York. They were examining the statue of Prometheus, when one of them asked, "Who's that supposed to be?"

"Are you kidding?" rejoined the other. "Why, that's Promiscuous!"

Standing in a crowded street car, a rather buxom woman was vainly trying to find a token for carfare.

All her pockets had been tightly buttoned as a precaution against pickpockets, and no little commotion resulted.

"Please let me pay for your fare," said the man beside her.

"Nothing of the kind," she replied, continuing the search. "I've got the fare here somewhere."

"I'm sure of it lady," said the man, "but I'd like to pay your fare. You've unbuttoned my suspenders three times already."

* * *

A small girl was taken to church for the first time. When everyone knelt down, she whispered:

"What are they going to do?"

Her mother whispered back, "They are going to say their prayers."

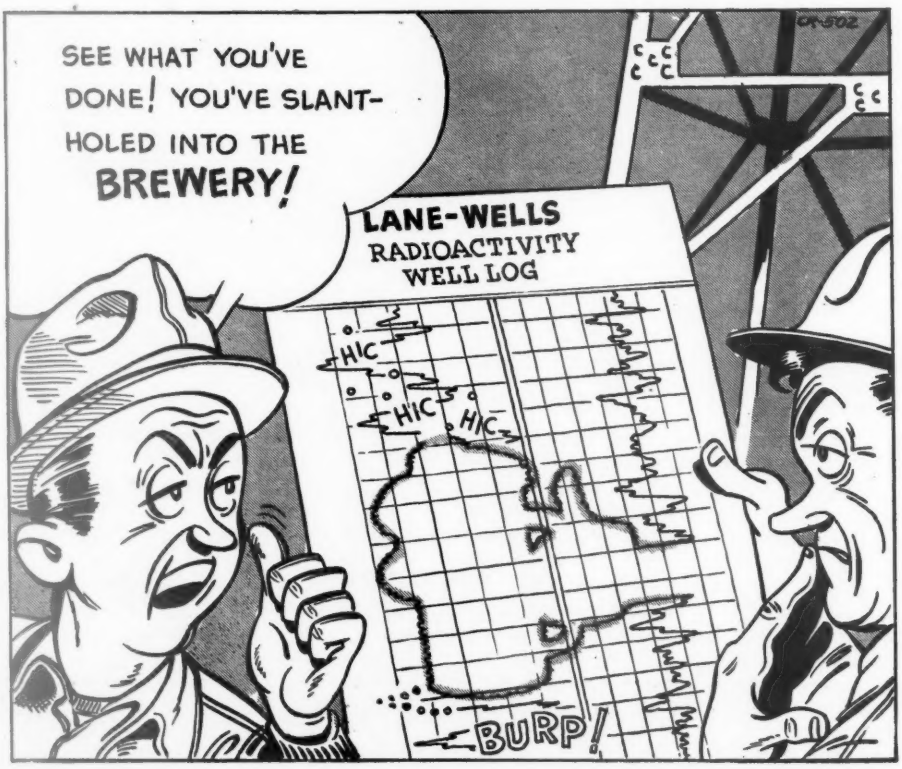
Little Girl (looking up in amazement, then in a loud voice):

"What, with all their clothes on?"

* * *

The girl on the bus was reading about birth and death statistics. Suddenly she turned to the male beside her and said, "Do you know that every time I breathe a man dies?"

"Very interesting," he returned, "why don't you try Sen-Sen?"



A young matron resigned her secretarial position. She said, "My reason will soon be apparent, and so will I."

* * *

He: But you promised at the altar to obey me.

She: Of course, I didn't want to make a scene.

* * *

Office Manager: Young lady, in the matter of dress, don't you think you could show a little more discretion?

Flapper Fanny: My gosh! Some of you guys ain't never satisfied.

* * *

A lady wrote a large mail order house inquiring about the price of toilet tissue. In due time she received a reply: "Please refer to page 410 of our large catalog."

She immediately replied: "If I had 410 pages of your catalog I wouldn't be writing you."

* * *

Mandy, Ah sho' laks yo' suit.
Sho' nuff?
Sho' do!

* * *

Pedestrian: A man whose wife beats him to the garage.

* * *

Etiquette is learning to yawn with your mouth shut.

* * *

To make a long story short: Don't tell it.

* * *

Wife to husband who had a few drinks too many: "If it were the first time, Henry, I could forgive you, but you came home like this in November, 1916."

* * *

Patient: The size of your bill makes my blood boil.

Doctor: That will be twenty dollars more for sterilizing your system.

* * *

Single girls aren't the only ones looking for a husband.

* * *

"I'm a self-made man."

"You're lucky. I'm the revised work of a wife and three daughters."

* * *

"The ladies of this church have cast off clothing of all kinds. Come and see them in the church basement anytime this week."

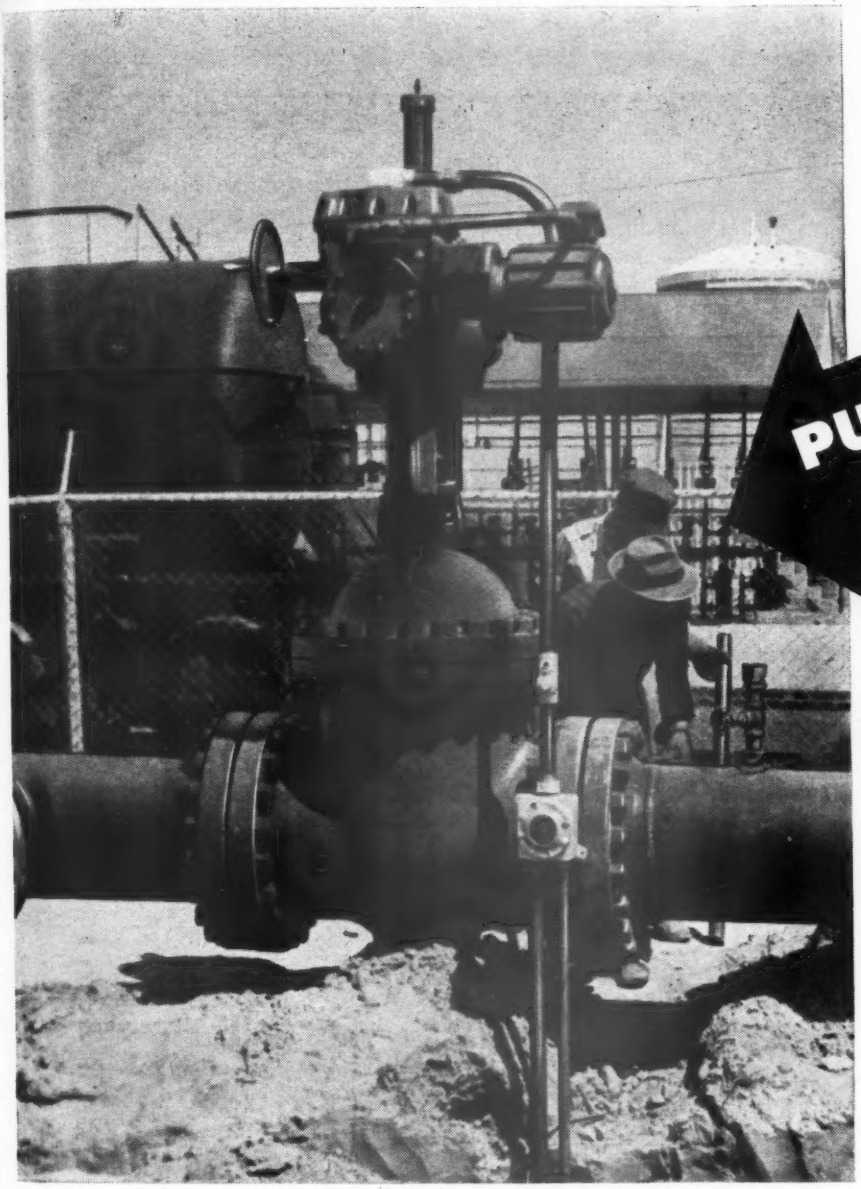
* * *

DOUBLE-TALK

Everyone will acquiesce
Taxes cause us much distress.
The budget figures I survey
Sometimes take my breath away.
But figures of another kind
Are also boldly redesigned.
Once, a woman's winsome curves
Helped to soothe my frazzled nerves.
Now I view them with suspicion
Born of optic erudition.
Are they physically gifted
Or, like taxes, just uplifted?

—Ivan J. Collins.

To obtain more information on products advertised see page E-49



PUT IT IN... FORGET IT!

it's a Darling pipe line gate valve

Typically, this motor-operated, 18" Darling cast steel gate valve of the fully revolving, double disc parallel seat type, is now cutting costs and maintenance on a major cross-country products line.

WHEN it's a Darling pipe line gate valve you *can* forget it—for longer than you ever thought possible! Despite extreme temperature changes, despite severe line stresses, this valve closes tight every time. It requires less maintenance. You get *surer* valve performance, year in, year out.

It's all a matter of principle—a unique but simple one—*Darling's fully revolving, double disc, parallel seat* principle! It automatically compensates for valve body distortion, equalizes disc and seat wear, cuts down-time and maintenance to the bone!

Get *all* the facts—money-saving, time-saving facts that make these Darling gate valves preferred equipment today in all kinds of oil and gas line service everywhere. Simply outline your particular service needs or ask for a complete descriptive bulletin.

DARLING VALVE & MANUFACTURING CO.

Williamsport 2, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

DARLING TRADE DARLING MARK VALVES

OIL and GAS TRADE NEWS

Army Research Unit Sponsored By Waukesha

A United States Army research unit, formally designated as the 983rd Q. M. Petroleum Products Laboratory (Mobile), will begin operations in Waukesha, Wisconsin, in the near future under the sponsorship of the Waukesha Motor Company. The principal work of the unit will be research into the characteristics of motor fuels and general lubricants used by the Armed Services, and training in operational and maintenance procedures in connection with the fuel rating laboratory engines manufactured by the Waukesha Motor Company. The fuel research laboratories of Waukesha as well as classroom facilities and space for equipment storage will be made available to the unit.

California Agents Named

Robert A. Fergusson, president of The Rust-Oleum Corporation, Evanston, Illinois, recently announced the appointment of The Republic Supply Company of California as a new distributor for Rust-Oleum rust-preventive products. Republic Supply of California is at 2600 South Eastland, Los Angeles.

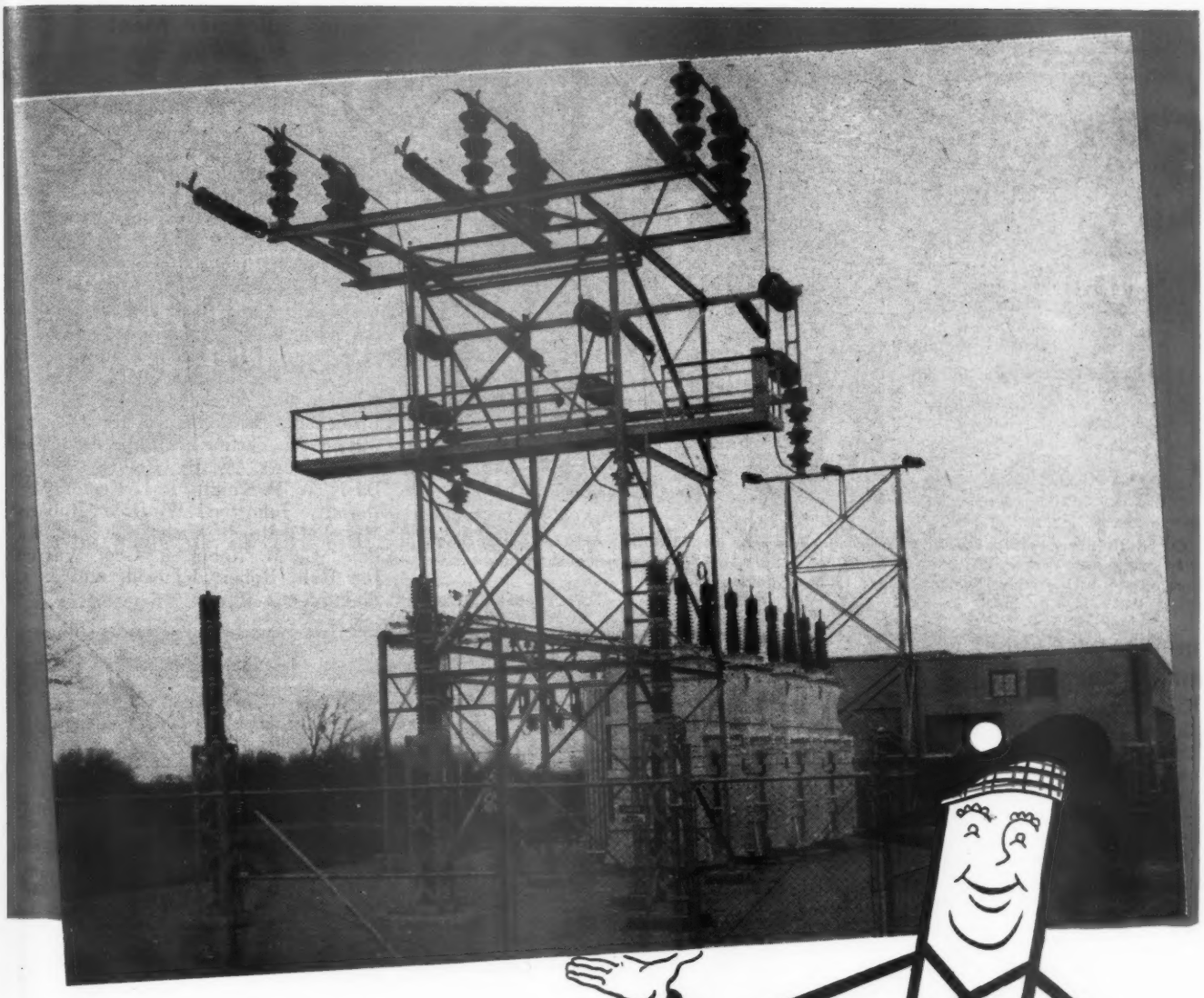
Plant Expansion Approved

General approval to a project costing approximately $15,000,000 for increased facilities of the Springfield, Illinois, works, tractor division, was given by the board of directors of the Allis-Chalmers Manufacturing Company recently.

More than 300,000 sq ft of manufacturing floor space, and the necessary machine tools for increased production of crawler tractors, motor graders, and repair parts will be included in the program. The addition will be east of the main building of plant No. 1.

Top Management of Dresser Industries, Inc. convened recently in Los Angeles in the first of a series of continuing quarterly executive management training conferences. Shown attending the meeting are: A. R. Weis, president, Pacific Pumps; R. E. Reimer, vice president, secretary-treasurer, Dresser; H. P. Boncher, general manager, Dresser Manufacturing, vice president, Dresser; H. N. Mallon, president; R. P. Brown, director of personnel and organization planning; J. B. O'Connor, executive vice president; T. L. Moody, director, industrial relations, Dresser. In second picture, first row, are: D. A. Johann, general sales manager, Roots-Connersville; R. R. Newquist, executive vice president, Roots-Connersville; H. Z. Hight, sales manager, Dresser. Back row, Max B. Campbell, vice president, Security Engineering; A. E. Harvey, vice president, Stacey Brothers.

Also Attending the Meeting were: George H. Moore, sales manager, Magnet Cove Barium; E. J. Weis, vice president, Pacific Pumps; L. E. Moffatt, manager special products sales, Dresser Manufacturing. Seated: R. A. Donbar, president, Mid-Continent Division, Pacific Pumps. In second picture are: G. W. Walton, vice president, IDECO; H. H. Lancaster, Jr., Magnet Cove Barium; W. F. Slater, manager, hydraulic sales, Kobe, Inc.; G. W. Probst, western regional sales manager, Clark Bros., F. W. Laverty, general sales manager, Clark Bros.



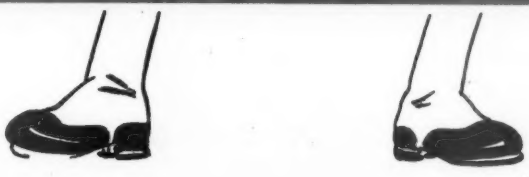
I'm shouldering the Power Load for Pipeline Operators . . .

This Crude Pipeline Station, operated by a major company, in Osage County, Oklahoma, utilizing 1-1500 HP motor, 2-1250 HP motors and 1-750 HP motor is powered by Low Cost Electric Power. Yes, PIPELINE OPERATORS have discovered, regardless of the job to be done in moving fluid, that Purchased Electric Power can do it more satisfactorily—*and for less.* Simplify YOUR power problems with Electric Power. Call your nearest Electric Service Company—NOW!

Petroleum Electric Power Association

ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY

CALL YOUR NEAREST ELECTRIC SERVICE COMPANY FOR MORE FACTS OR ADDRESS YOUR REQUEST TO P. O. BOX 2771, DALLAS, TEXAS



A. O. Smith Corporation Building. Welding equipment manufacturing of A. O. Smith has moved into this Milwaukee, Wisconsin building. The building houses experimental shops and sales offices as well as assembly lines for Smith's 12 basic welder models.

Rector Salesmen Meet In Fort Worth, Texas

At their annual sales meeting, held in Fort Worth recently, the sales organization and division managers of Rector Well Equipment Company, Inc., were given a report of the past year's activities, which was one of the best in the company's 20 year history. L. L. Rector, president, and J. L. Pinkard, sales manager, outlined sales and production plans for the coming year.

Present were: Back row, C.M. Kestler, Don C. Davis, John L. Curry, Geo. H. Stewart, C. L. Cron, Fred H. Overdorf, Geo. E. Milligan, R. M. White, J. G. Brannon, Geo. S. Badger, E. W. Brockman, B. V. Fisher, R. B. Yanaway, C. W. Zartman. Middle row, Myrl O. Andrews, W. H. Counts, M. C. Davis, W. P. Knight, L. L. Rector, Mrs. Dorothy Johnston, Winifred Roberts, Mrs. J. U. Brown. Front row, A. J. LaBate, G. M. Robinson, Geo. Warren, Joe Holt; Robert Kincaid, and J. L. Pinkard.

Continental Holds 12th Annual Sales Meeting

Continental Supply Company held its 12th annual sales meeting in Houston recently. Over 200 were in attendance, including district managers, assistant district managers, and field representatives from the company's 80 stores and offices, as well as principals in the sales and engineering divisions of the company.

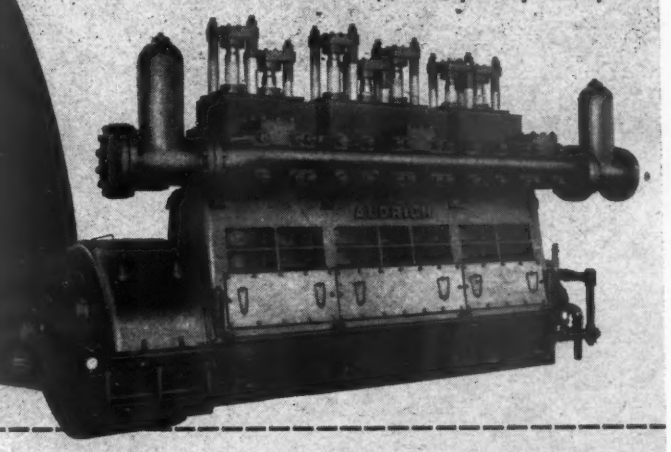
The theme of the meeting was "Know Your Products". Each session was one of demonstration so that all personnel would be fully informed on latest development in equipment they handle. One day was spent in the plant of the Emsco Derrick and Equipment Company, at which time the group inspected various pieces of Emsco equipment. Each phase of the tour was accompanied by explanatory talks.

Rector salesmen attending annual sales meeting.

Sales and operating men of Welex Jet Services, Inc., gathered in Fort Worth, Texas, recently for the company's general sales meeting. They are, top row: Jack Smith, Ray Williams, John Sherrod, C. R. "Chick" Parker, George Jefferis, K. L. White, Bob Burns, Joe Wooldridge, Joe Beard, John Flemming, Art Harper, W. O. Foerster, Ray Porter, E. L. Blackman, O. B. Avent, and L. B. Putman. Second row: W. L. Carwile, Jr., W. O. Satterwhite, W. H. Griffin, Dr. W. C. Ford, R. H. McLemore, T. R. Weymouth, II, Tom Painter, Blake Caldwell, A. M. "Bert" Birnie, and W. K. Daggett. Bottom row: R. L. Robinson, James E. Staugh, Howard Shireman, R. C. Starrett, Ray Graham, H. A. Bergman, W. B. Clark, and R. H. Cossey. General headquarters for Welex Jet Services, Inc., are situated at Fort Worth.

FOR THESE SERVICES:

water flooding, salt water disposal, lean oil service, crude and gathering lines, bottom hole pump service, product lines, pumping liquids such as butane, propane, ethylene, diethylene glycol, etc.



3½" x 6" Septuplex. 250 rpm.
15,000 bbl per day. 2020 psi.

Oil Men Select Aldrich Direct Flow Pumps because

. . . operating speeds are high. You get whatever volume and pressure you need from a smaller, lighter, more compact pump.

. . . fluid-ends are sectionalized. Parts can be replaced at low cost and can be made of stainless steel, bronze, Monel or other special materials necessary for corrosive fluid service.

. . . maintenance is simplified. No more tapered bores in the working barrel to make valve removal difficult. Now, manifolds slide out on studs and you can lift out valves as complete units. Packing is very easy to renew due to the accessibility of the stuffing boxes.

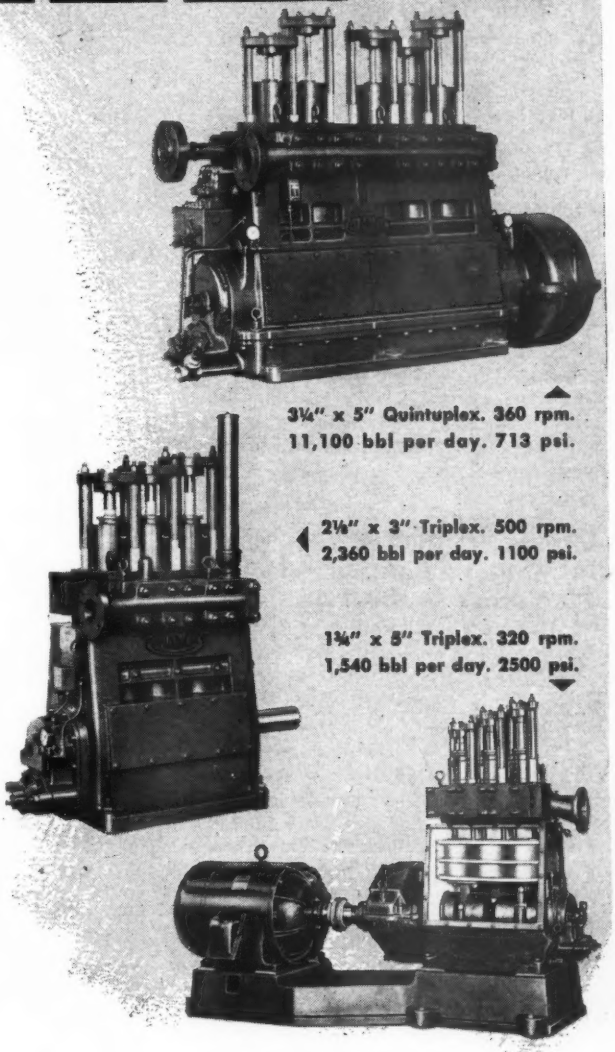
. . . plunger sizes are changeable. In many cases it is only necessary to add—besides plungers—new glands, throat bushings and packing to the same fluid-end. "Kosmos" Porcelain Plungers are standard for salt water service.

. . . wearing parts are interchangeable among 3, 5, 7 and 9 plunger pumps of the same stroke sizes. This minimizes spare parts costs and inventories.

. . . ample stocks of spare parts are maintained at Mid-Continent and California locations.

For information or catalogs, contact your nearest Aldrich representative . . . or write us direct.

Statistics shown here are for pumps operating on actual projects. Other size pumps, other volumes and pressures are available.



3¼" x 5" Quintuplex. 360 rpm.
11,100 bbl per day. 713 psi.

2½" x 3" Triplex. 500 rpm.
2,360 bbl per day. 1100 psi.

1¾" x 5" Triplex. 320 rpm.
1,540 bbl per day. 2500 psi.

THE ALDRICH PUMP COMPANY

26 PINE STREET • ALLENTOWN, PENNSYLVANIA

...Originators of the Direct Flow Pump

Representatives: P. H. Arden, P. O. Box 185, Glenview, Ill. • Bushnell Controls & Equipment Co., 3929 W. Jefferson Blvd., Los Angeles 16, Calif. • L. T. Gibbs, 509 Petroleum Bldg., Tulsa 3, Okla. • R. B. Moore Supply Co., Inc., Bolivar, N. Y. • Power Specialty Co., 2000 Kipling St., Houston 6, Texas • Reeves & Skinner Machinery Co., 2211 Olive St., St. Louis 3, Mo. Stearns-Roger Manufacturing Co., 1720 California St., Denver 2, Colo. • Export Sales: Petroleum Machinery Corp., 30 Rockefeller Plaza, New York 20, N. Y. • Birmingham • Boston • Buffalo • Cincinnati • Cleveland • Detroit • Duluth • Jacksonville • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. • San Francisco • Seattle • Spokane, Wash. • Syracuse

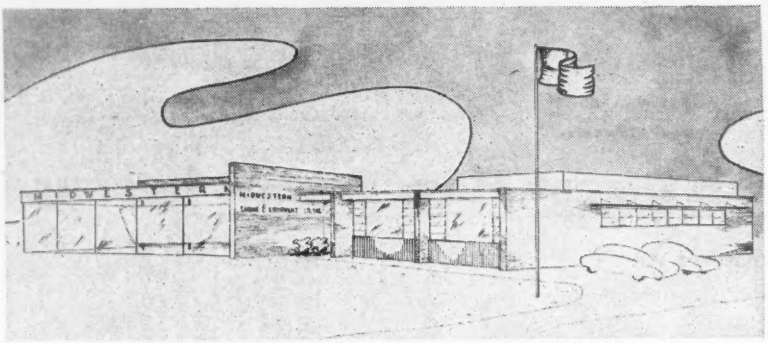
Hill, Hubbell men attending 16th annual sales conference.

Hill, Hubbell Holds Annual Sales Meeting

Hill, Hubbell and Company's 16th annual sales meeting for 1952 was held recently at Chicago's Edgewater Beach Hotel with sales, production, and advertising problems of the pipe wrapping industry taking top priority in the three-day meeting. Guest of honor was H. L. Jones, president of General Paint Corporation of San Francisco, of which Hill, Hubbell is the Eastern pipe coating and wrapping division. Shown in picture accompanying are: C. D. Cobbett, George Hudock, M. M. Bowen, H. L. Jones, Bryan Patterson, R. J. Young, Chuck McGarvey, and R. A. McCarthy.

"Oilwell" Acquires New Los Angeles Offices

New offices and warehousing buildings have been acquired by the Oil Well Supply Division of U. S. Steel Company at 49th Street and Santa Fe Avenue, Los Angeles, California. The new property contains two buildings, covering a total of 54,300 sq ft. There is also a paved yard of an additional 26,430 sq ft.



Artists' drawing of Mid-Western Engine and Equipment's new Oklahoma plant.

New Building Plans Set Up

O. E. Murrey, president of the Midwestern Engine and Equipment Company, announced construction plans for a new building on Sapulpa Road near Tulsa, Oklahoma. Midwestern officials stated that the company had "outgrown" its present quarters, since its inception in March of 1946. The company began as exclusive distributor for Continental Motors and Owens-Corning Fiberglass pipe wrap.

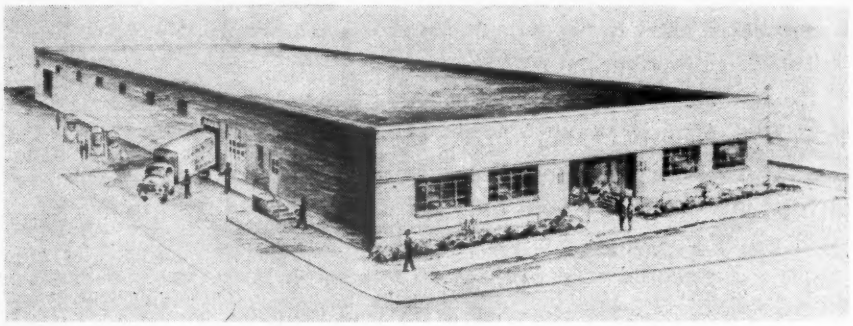
Change Announced in Worthington Company Name

Stockholders of Worthington Pump and Machinery Corporation at their annual meeting re-elected their present board of directors and voted to change the company's name to Worthington Corporation.

H. C. Ramsey, president, stated that because "of our wide diversification we believe that the continued reference to 'pumps' in the corporate name tended to lead the public into the erroneous conclusion that pump manufacture was our only endeavor. Such, of course, is not the case."

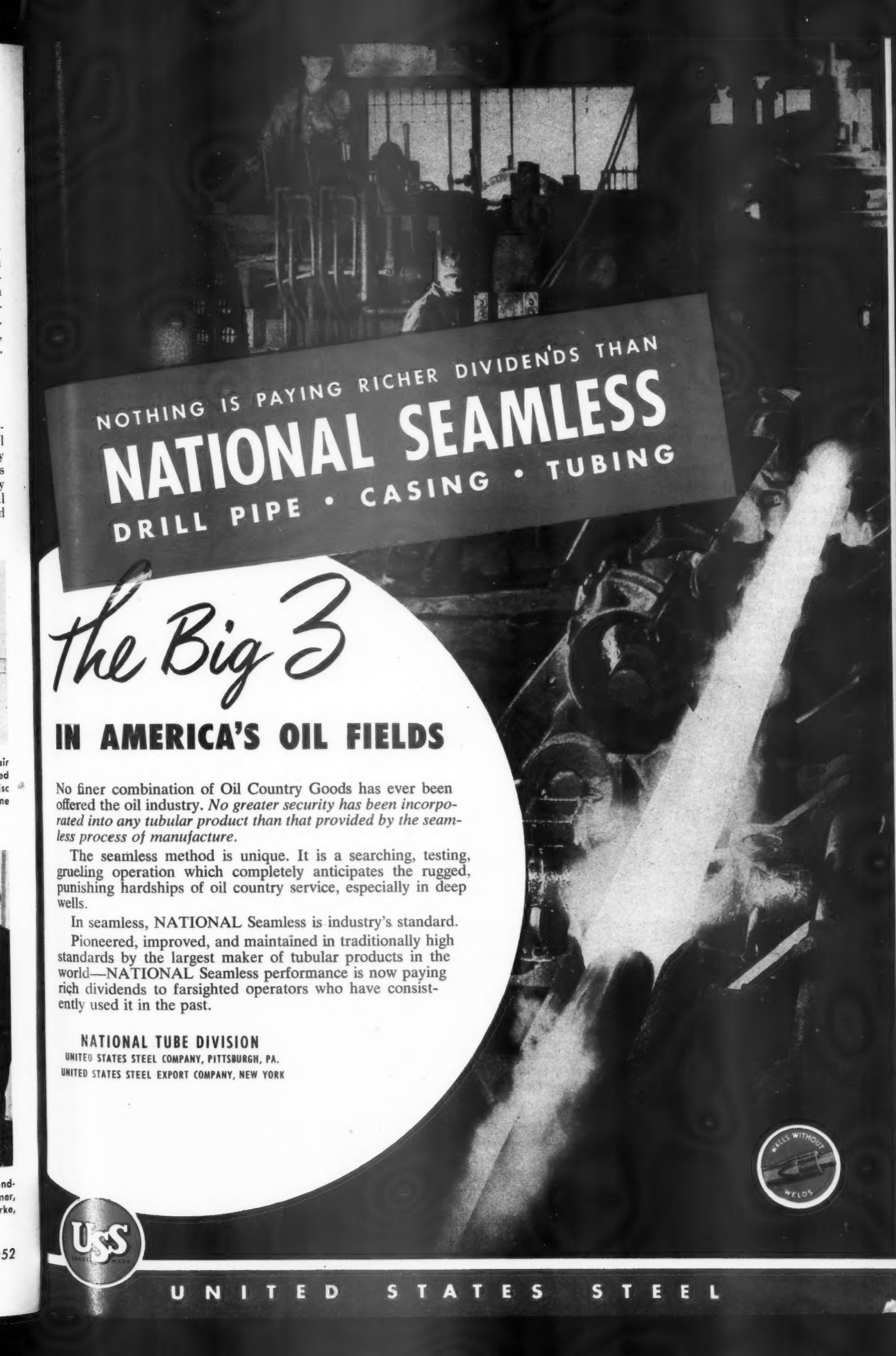
Rust-Oleum Names Five New Agents

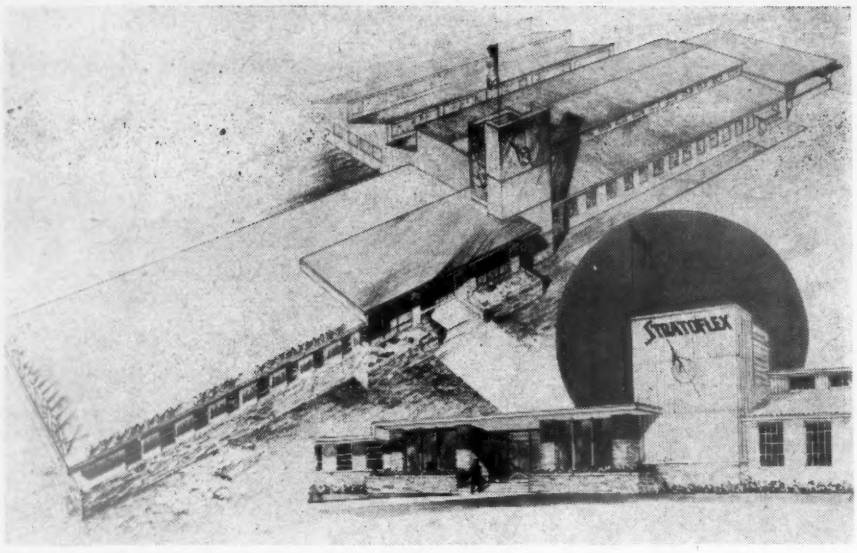
The Rust-Oleum Corporation has announced the addition of five new industrial distributors to its distributor sales organization throughout the country. The new distributor firms are: Adkins Company, Berlin, Maryland; Mill and Contractors Supply, Wilmington, North Carolina; Warren Hardware, Warren, Ohio; American Radiator and Standard Supply Corporation, Zanesville, Ohio; and Couch and Heyle, Peoria, Illinois.



Twin-Disc Dallas Offices. New quarters of Southwest factory branch office and parts repair depot of the Twin Disc Clutch Company, at 1511 Turtle Creek Boulevard, Dallas, Texas, occupied early in 1952. Expanded facilities permit 8000 sq ft for repair shops and parts for Twin Disc hydraulic torque converters, industrial fluid drives, friction clutches, power take-offs, and marine reverse and reduction gears.

Baash-Ross Sales Personnel operating in the Texas and Gulf Coast areas met recently. Attending were: H. Z. (Zeke) Browning, George Cook, Charles Laudermilk, Cecil Laws, Gene Buckner, Ken Jones, Albert Schoettler, John Terry, J. L. Barnett, Jr., E. J. Frederick, and E. M. Gearke, general sales manager.


NOTHING IS PAYING RICHER DIVIDENDS THAN
NATIONAL SEAMLESS
DRILL PIPE • CASING • TUBING
the Big 3
IN AMERICA'S OIL FIELDS
No finer combination of Oil Country Goods has ever been offered the oil industry. *No greater security has been incorporated into any tubular product than that provided by the seamless process of manufacture.*
The seamless method is unique. It is a searching, testing, grueling operation which completely anticipates the rugged, punishing hardships of oil country service, especially in deep wells.
In seamless, NATIONAL Seamless is industry's standard.
Pioneered, improved, and maintained in traditionally high standards by the largest maker of tubular products in the world—NATIONAL Seamless performance is now paying rich dividends to farsighted operators who have consistently used it in the past.
NATIONAL TUBE DIVISION
UNITED STATES STEEL COMPANY, PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK
WELLS WITHOUT WELDS
USS
UNITED STATES STEEL



New location of Stratoflex, Inc., in Fort Worth.
Company name was formerly Aeroquip Sales and Engineering.

Stratoflex, Inc., Moves to New Fort Worth Plant

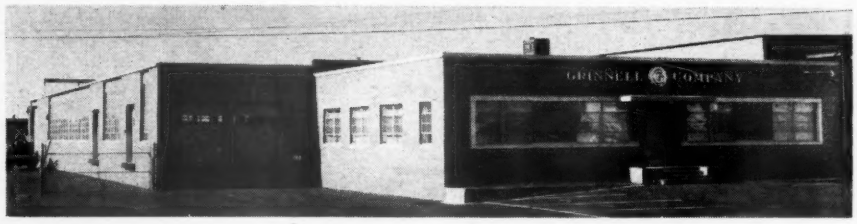
The board of directors of Aeroquip Sales and Engineering, Inc., has announced a change in the name of the company to Stratoflex, Inc., and the relocation of general offices, laboratory and factory facilities at 220 Roberts Cut-Off, Fort Worth, Texas. Also announced were new officers for Stratoflex, Inc. K. W. Davis, president; J. E. Everroad, executive vice president; S. R. Billingsley, vice president — engineering; W. R. Cook, vice president—sales; N. E. Barber, secretary-treasurer; H. E. Reese, assistant secretary and J. D. Willis, purchasing agent.

Koehring Names New Agent

Recently appointed Koehring distributor for the entire state of Minnesota, the Ruffridge-Johnson Equipment Company, will handle the complete line of Koehring heavy-duty construction equipment along with products of the three Koehring subsidiaries, C. S. Johnson, Parsons, and Kwik-Mix. Ruffridge-Johnson succeeds Rosholt Equipment Company as the area Koehring representative. C. T. Johnson heads the firm as president and sales manager, L. C. Ruffridge is vice president.

The complete line of Koehring now available under Ruffridge-Johnson representation includes: Koehring excavators, cranes, draglines, holes, etc.; Johnson aggregate and cement plants, batchers, bins, storage silos, clamshell and concrete buckets; Parsons Trenchliners for trench excavation; and Kwik-Mix concrete, bituminous, plaster-mortar mixers and the Moto-Bug.

Ruffridge-Johnson Equipment Company is situated at 250 Tenth Avenue, South Minneapolis, Minnesota. D. E. Thompson is parts manager of the company.



New Grinnell warehouse in Dallas, Texas, which houses fire protection fabricating shop and sales office.

Grinnell Opens New Office

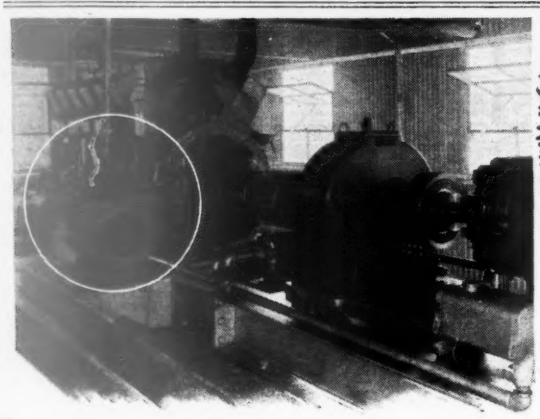
Grinnell Company has opened a new factory warehouse, fire protection fabricating shop, and sales office at 161 Glass, Dallas, Texas. Grinnell home offices are in Providence, Rhode Island, but offices have been maintained in Dallas for 45 years, formerly at 1315 Marilla Street. T. E. Collins is manager of the fire protection department and J. E. Hatt manages the supply sales department.

Supply Company Moves

Sig Iverson, president of Iverson Supply Company, has just announced that the company's Midland, Texas, office has been moved to 419 Midland Building, under the supervision of Henry Oliver, district manager.

Gray Is Assistant Manager For Pittsburgh Coke

The appointment of Arthur E. Gray as assistant manager, tar base coatings has been announced by O. E. McCullough, manager of the protective coatings division of the Pittsburgh Coke and Chemical Company. Prior to joining Pittsburgh Coke, Gray was affiliated with the Pipe Protection Service, Incorporated, where he served as vice president and sales manager.



POWER TO FIT THE MACHINE

POWER TO FIT THE JOB

WISCONSIN-POWERED *Starting Unit Assures Fast Starts*

Big engines don't deliver dependability unless the starting engine *starts every time* . . . which is why the great majority of power users, 3 to 30 hp., feel safer when the starting engine bears the name "Wisconsin," as typically illustrated here.

The way a Wisconsin Engine is built is a clue to its dependability and universal acceptance. Both ends of every crankshaft ride on tapered roller bearings, preventing bearing failure. Every Wisconsin cools by air . . . no winter freeze ups or summer overheating. And an OUTSIDE magneto with impulse coupling assures easy-servicing, but most important, quick starts and steady, all-season dependability.

These are the features *behind* the *far ahead* performance of Wisconsin-powered equipment.

4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 30 hp.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
619 S. MAIN STREET, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

in WIRE ROPE, too load strain calls for SPECIALIZED muscles

Everything looks upside down to the three-toed sloth. Unique among animals, he prefers to live his life dangling downward from the top branches of tall trees. Helping him to survive in his topsy-turvy world are highly specialized and powerfully developed rear and forelimb muscles.

In wire rope, too, specialized jobs call for the right kind of muscle. Load strain! Bending fatigue! Shock stress! Abrasion! Each calls for wire rope that best combines the required resistance characteristics.

Complete quality control from ore to finished rope; long experience and specialized know-how—these are your assurance that in Wickwire Rope you always get the proper combination of physical properties for long-lasting, reliable service on your particular job.

For additional information write or phone our nearest sales office.

LOOK FOR THE YELLOW TRIANGLE ON THE REEL

THE COLORADO FUEL & IRON CORPORATION—Abilene (Tex.) • Denver • Houston • Odessa (Tex.) • Phoenix • Salt Lake City • Tulsa
THE CALIFORNIA WIRE CLOTH CORPORATION—Los Angeles • Oakland • Portland • San Francisco • Seattle • Spokane
WICKWIRE SPENCER STEEL DIVISION—Boston • Buffalo • Chattanooga • Chicago • Detroit • Emlenton (Pa.) • New York • Philadelphia

WICKWIRE ROPE

CF&I

PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION

Regional service representatives for Cummins Engine attending a three-day meeting in Columbus, Indiana.

Cummins Regional Men Meet

Regional service representatives of Cummins Engine Company, Inc., recently attended a three day meeting at Columbus, Indiana. In accompanying photo are: Dillard Davis, central regional office, Chicago; Leon O'Neal, southwestern regional office, Los Angeles; Norman Grimes, southeastern regional office, Atlanta; Richard Carlson, eastern regional office, New York City; Ralph Shields, northwest regional office, Seattle; Jack Mitchell, Great Lakes regional office, Cleveland, and Arch Herron, Rocky Mountain office, Denver.

Richardson X-ray Moves

The Richardson X-Ray Service Corporation has moved the Western headquarters of the company into new and enlarged office and shops at 617 Raymond Avenue in Alhambra, California, according to R. A. "Rusty" Richardson, Jr., president. Announcement also has been made of a new branch manager. C. W. Radcliff, welding expert and formerly welding inspector for Texas Illinois Gas Pipe Line Company. Radcliff is credited with the first inspection work in foreign fields. He will have offices at 6707 Foster Street, Houston.

Toledo Pipe Tools Sees Its 50th Anniversary

Toledo Pipe Threading Machine Company, established in 1902, and one of the nation's pioneer manufacturers of pipe threading tools and power pipe machines, is celebrating its 50th anniversary. The "Toledo story" is told in a handsome brochure now being sent to distributors and jobbers for distribution to their customers. William W. Vosper, chairman of the board, made a revolutionary improvement in the method of threading pipe 50 years ago when he invented a pipe tool employing the receding die principle. Instead of solid dies, segments were used with only enough teeth on their cutting edge to form a thread—thus reducing friction and making it much easier to operate the tool. Also, as the thread was cut the dies receded which further relieved friction.

In 1914 the first section of the present-day plant was erected on the banks of the Maumee River, in Sandusky, Ohio. In recent years, both the plant and the company's line of products have been expanded to include a complete range of hand-operated tools for cutting, threading and reaming pipe from ⅛ to 12-in., and ¼ to 1-in. bolts; also high-production power pipe machines, up to 2 and 4-in. capacity; and portable power drives for operating geared threaders and many other applications.

Durban A. Longenecker is president and treasurer, as was his father.

OIL RECLAIMER

FILTER

HILCO LUBE and FUEL OIL PURIFICATION - - -

15 YEARS CONTINUOUS OPERATION WITHOUT OIL CHANGE IN DIESEL AND GAS ENGINES—NEGLIGIBLE PISTON AND CYLINDER WEAR.

THIS IS THE RESULT OF COMPLETE PURIFICATION—THE REMOVAL OF SLUDGE, CARBON, ACIDS, WATER, AND FUEL DILUTION.

HILCO UNITS IN OPERATION LONG ENOUGH TO PROVE THEIR VALUE. ONE-QUARTER CENTURY OF EXPERIENCE IS AT YOUR SERVICE.

- PURIFIERS
- FILTERS
- RECLAIMERS
- CONDITIONERS

THERE IS A **HILCO** FOR EVERY LUBRICATION AND FUEL OIL FILTERING PROBLEM - - -

YOU WANT CLEAN OIL AND CLEAN ENGINES TO SAVE EQUIPMENT—OIL AND MONEY—INVESTIGATE HILCO OIL MAINTENANCE METHODS.

★ WRITE FOR FREE LITERATURE - - NO OBLIGATION

THE HILLIARD CORPORATION, 209 W. FOURTH STREET, ELMIRA, N. Y.

IN CANADA—UPTON-BRADEEN-JAMES, LTD., 990 BAY STREET, TORONTO, 3464 PARK AVE., MONTREAL

Oliver Makes Changes in Products and Personnel

Recently acquired from Europe, where it has been used extensively in the pulp and paper industry, Oliver United Filters, Inc., has developed for

P. J. McGuire

C. W. Crumb

W. H. Pitkin

use in the United States the Oliver-Ahlfors "Upflow" vibrating pulp screen, particularly suited for primary and secondary screening of all types of bleached and unbleached pulps. Instead of a downward gravity flow of pulp, the Oliver-Ahlfors screen operates with an upward flow.

Another recent innovation by Oliver United is the development of the Oliver-Morton diffuser offering a system for continuous extraction of sugar from sugar beet cossettes, as opposed to the present conventional batteries of batch type diffusers.

One of the most recent developments in the Centriclone. This is a liquid cyclone for de-sliming, classifying, and thickening various slurries in the chemical, food, and related industries.

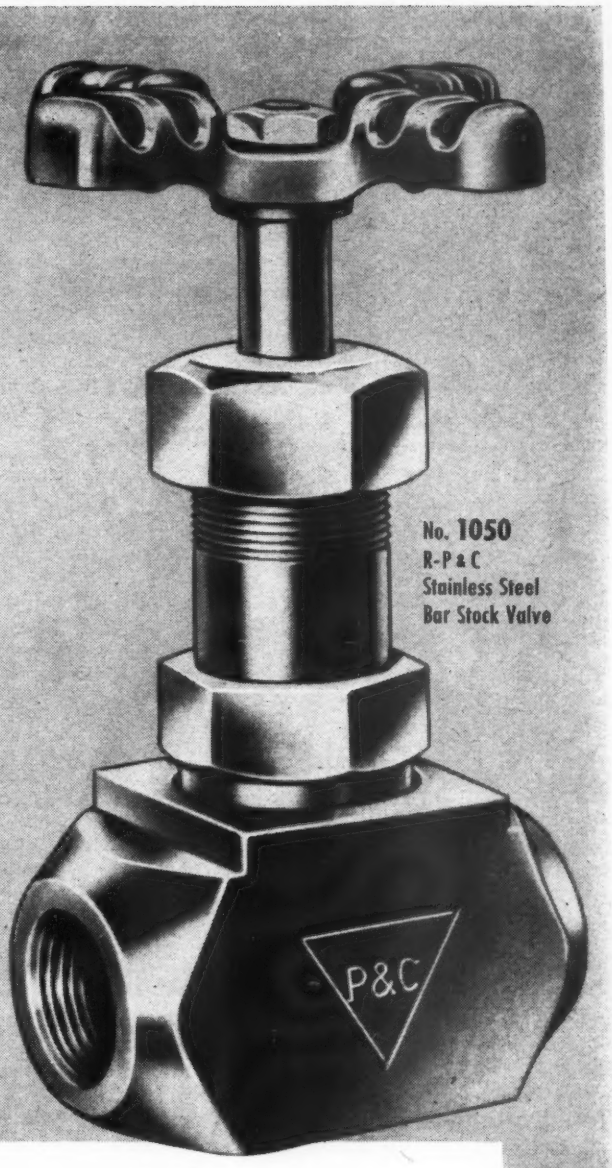
To implement this expansion program, and coordinate the development of such new items, Oliver United Filters announce the appointment of Philip J. McGuire as director of research and development who will assume the supervision and activation of this office. McGuire has been with the company 26 yr, of which the last 9 were as Western division sales manager. He will be succeeded as Western division sales manager by James B. Hoxie, associated with the organization for 20 years.

Concurrent with these changes, Oliver United Filters is consolidating and centralizing its departmental organization at the home office in Oakland, California, with the transfer to that office from New York of Ward H. Pitkin, assistant general sales manager, and Carlton W. Crumb, sales promotion manager.

Worthington Holds Meetings

District sales managers' conferences were held in six plant cities by Worthington Corporation, according to T. J. Kehane, assistant vice president and general sales manager for the corporation. Shop tours, sales problems discussions, and new product exhibitions were featured at conferences at Worthington plants at Wellsville, and Buffalo, New York; Holyoke, Massachusetts; Harrison, Dunellen, and Succasunna, New Jersey. Purpose is to bring sales managers up to date on product improvements, etc.

an ACCO product



No. 1050
R-P & C
Stainless Steel
Bar Stock Valve

RUGGED...

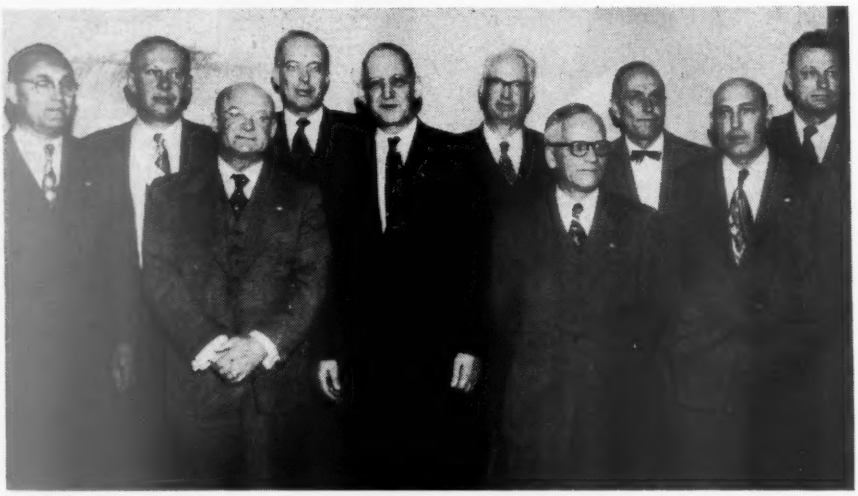
• That's the best way to describe R-P&C Bar Stock Valves. These fine throttling valves provide precise, positive flow control. Long, low-cost, trouble-free service makes them ideal for meter, gauge, test, and general purpose use. Precision turned . . . from carefully tested metals . . . and suitable for a wide range of pressures and temperatures.

See your R-P&C distributor or write the nearest R-P&C district office for information.

ACCO
R-P&C VALVE DIVISION
AMERICAN CHAIN & CABLE
TRADE MARK
Reading, Pa., Atlanta, Baltimore, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

R-P&C valves

Site of Roebling's Sons Company's new Los Angeles quarters, which houses the district offices and warehouse.



Ten Dowell men receives 20-yr service pins at celebration of the company's 20th anniversary.

Ten Dowell Men Receive Twenty-Year Service Pins

The 10 men above represent 200 years with Dowell, Inc., oil well servicing and industrial cleaning firm. Dowell is celebrating its twentieth anniversary this year and these men were those awarded 20-year service pins. They are Dr. John Grebe, Midland, Michigan; Charles Mangold, Tulsa, Oklahoma; James A. Cummin, Wichita, Kansas; John G. Staudt, Tulsa; Robert D. Shaw, Tulsa; Dr. W. R. Veazey, Midland; Dr. A. P. Beutel, Freeport, Texas; Nelson Griswold, Freeport; Dewey Wyman, Reed City, Michigan, and Charles Prince, Shreveport, Louisiana.

Atlas Company Moves

Atlas Heat Treating Corporation has recently moved into its new and expanded headquarters adjacent to Web Wilson Oil Tools, Inc., Los Angeles. Atlas Heat Treating is now equipped to do all the heat treating for Web Wilson, and, in addition, is doing heat treating work for other industries in the oil field and allied lines. Officers of Atlas Heat Treating are: W. A. Wilson, president, John W. Rife, secretary.

Roebling Plant Built

John A. Roebling's Sons Company recently moved its Los Angeles district office and warehouse into a new building at 5340 East Harbor Street. According to E. C. Low, vice president sales, the completion of the structure marks the latest step in the company's program of expanding its sales, warehousing, and product-assembly facilities. The Los Angeles branch formerly was situated at 216 South Alameda Street.

Vapor Recovery Appoints Two New Sales Agencies

Vapor Recovery Systems Company has announced the appointment of two new sales agencies in the Tulsa, Oklahoma, and Minneapolis, Minnesota area. The Tulsa agency, Arduser and Company, Tulsa will service the Oklahoma and Northeastern Texas area, Kansas and Nebraska. The Minneapolis agency of the Paul B. Mueller Company, Minneapolis, will serve the North Dakota, South Dakota, Minnesota, and Western Wisconsin area.

Roots-Connersville Is Incorporated by Dresser

Roots-Connersville Blower Corporation will be absorbed into the corporate structure of its parent, Dresser Industries, Inc., and thereafter will operate under the name, "Roots-Connersville Blower," a division of Dresser Industries, Inc., it was announced by R. H. Owens, president. Roots-Connersville will continue to operate as a separate, completely integrated organization at the same address.

Davison Appoints Agents

Krekel-Goetz Sales and Supply, Grand Rapids, Michigan, and Van Horn, Metz & Co., Inc., Philadelphia, have been named manufacturer's agents for Syloid 308 and associated products by The Davison Chemical Corporation. Syloid 308, added to lacquer, gives a semi-gloss or matte effect, similar to the hand-rubbed finish often given to furniture.

Inside the Atlas Heat Treating Corporation's new heat treating plant, into which they recently moved. It is adjacent to Web Wilson Tools, Inc., in Los Angeles, California.

For range of "availability for duty," you can't beat this small gate valve with the forged steel body and yoke. And it handles *every* job with the same Chapman top standard of performance. Here's why:

Any *extra stress* more than meets its match in the *extra strength* of the stem and wedge-gate connection. Added life for seat rings and gate faces is obtained by using super-hardened stainless steel. Seizing or galling of seating surfaces is prevented by gates (with certain types of trim) super-hardened by Chapman's *Malcomizing* process to at least 800 Brinell.

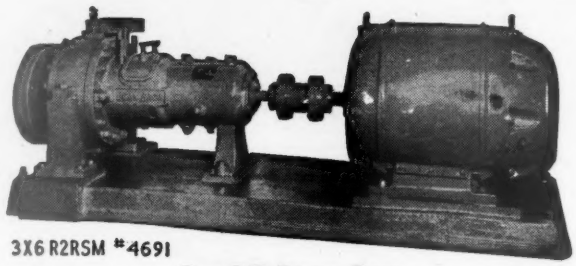
You can get List 960 in sizes from ½" to 2", and equipped with rising stem — either with yoke as shown above, or with inside screw. Bonnet joints are gasketed or metal-to-metal. Pressure range: 2,000 lb. at 100°F.—380 lb. at 1,000°F. For higher pressures, specify List 990. Catalog No. 10 is yours for the asking. Write to The Chapman Valve Manufacturing Company, Indian Orchard, Mass.

The CHAPMAN VALVE
Manufacturing Company
INDIAN ORCHARD, MASSACHUSETTS

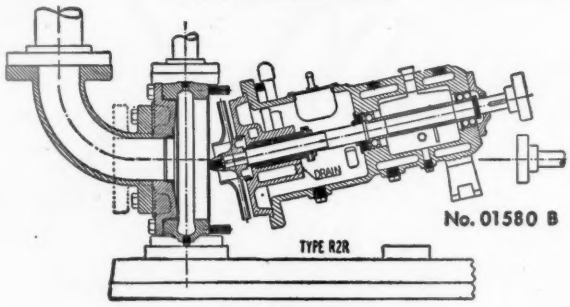
To obtain more information on products advertised see page E-49

DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



Type R2R Process Pump



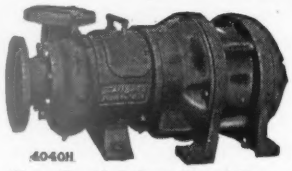
Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

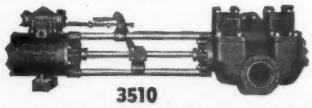
OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL and RECIPROCATING PUMPS



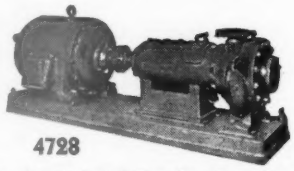
Close Coupled Centrifugal Pump



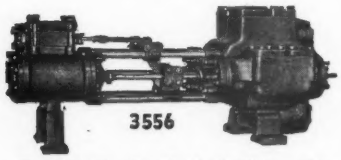
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

Representatives in Principal Cities

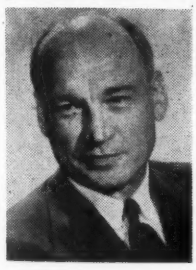
Lane-Wells Notes 20th Year

Lane-Wells celebrated its 20th birthday last month. Born in the depression the company pioneered gun perforating as an oil field service. In 1940 Lane-Wells introduced radioactivity well logging, a service that identified formations in either cased or uncased holes and permitted operators for the first time to locate potential producing zones back of well casing.

The more than 160 employees who have been with the company for over 10 years were honored in the March 1952 issue of the *Cablegram*. Walter T. Wells, a co-founder of the company, now chairman of the board, received the first 20-year service award.

New Beckman Center

Dr. A. O. Beckman, president of Beckman Instruments, Inc., The Helipot Corporation, and Arnold O. Beckman, Inc., announced this week that, to meet the steadily expanding space requirements of the Beckman organizations, approximately 40 acres have been purchased in the Fullerton - La Habra, California, area upon which will be built the facilities for the development and manufacture of precision instruments and advanced electronic equipment. Dr. Beckman emphasized that the program is a long range one, with various divisions and manufacturing units of the present Beckman operations being moved to the new La Habra location only as suitable facilities are completed. Steel restrictions make it impossible to estimate completion date of the building.



A. O. Beckman

Midwest Piping Moves To New, Larger Quarters

E. A. Kerbey, executive vice president of Midwest Piping and Supply Company, Inc., has announced the removal of the company's Eastern division offices to 50 Church Street, New York 7. This move provides aproximately twice as much space as occupied formerly, and was made to meet the needs of the growing business. L. C. Voyce is manager of the Eastern division.

"Oilwell" Moves Offices

West Texas district headquarters of U. S. Steel's Oil Well Supply Division, at Midland, Texas, have been moved to the recently completed V-J Tower Building in that city. V. J. Waters whose headquarters are at Dallas, is manager of "Oilwell's" Central Midwest area and D. O. Smith is assistant manager, in charge of the West Texas district. In addition to Smith, district office personnel include B. I. Castle and Dayton Blivens, city representatives; Mrs. Jane Parker, receptionist; and Miss Mary Moran, secretary.

To obtain more information on products advertised see page E-49

Tulsa Sales Office Open

Opening of a new sales office in Tulsa, Oklahoma, has been announced by Alan J. Bronold, sales manager for Sterling Electric Motors, Inc., of Los Angeles, to serve the state of Oklahoma. B. G. Jordan has been appointed manager of the Tulsa office. He is a graduate of the University of Oklahoma. The Tulsa area was formerly served by the Kansas City, Missouri office of Sterling Electric Motors, Inc.

B. G. Jordan

Steel Expansion Planned

A $65,000,000 expansion program that will increase Kaiser Steel Corporation's pig iron output by 50 per cent and raise steel ingot production by more than 11 per cent has been announced by Henry J. Kaiser, president. Principal facilities in Kaiser Steel's latest move to boost production of metal at its Fontana, California, plant are: A third blast furnace; a ninth open hearth furnace; 90 additional by-product coke ovens; 2 additional stands in the present hot-strip mill; major additions to equipment and housing at company-owned iron ore and coal mines.

France Packing Forms New Sales District

France Packing Company of Philadelphia, Pennsylvania, manufacturers of metallic packing, power piston rings, bakelite compressor rings, and valve discs, announce the formation of a new sales district with headquarters in Denver, Colorado. Raymond R. McCracken is the district manager and will cover Northern New Mexico, Colorado, Utah, Wyoming, Idaho, and Montana. His office is in Denver, Colorado. Until recently he was a district manager operating out of Chicago for Raybestos-Manhattan Co.

R. R. McCracken

Cameron Warehouse Open

Cameron Iron Works has announced the opening of a new warehouse and district headquarters offices at 900 Greffer Street, in Harvey, Louisiana. D. V. Clemons is district manager of the Louisiana, Mississippi, Gulf Coast Division. B. B. Biggs has been appointed warehouseman.

Other Cameron representatives in the Louisiana, Mississippi, Gulf Coast district include Fox Moses at Sulphur, Cal Grevemberg at Lake Charles, H. L. Evans and B. B. Bryan at New Iberia, George Myers at Baton Rouge, and W. C. Traweek at Houma.

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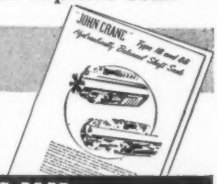

CRANE PACKING COMPANY

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Houston 11, Texas	Chicago 13, Ill.	Wilmington, Calif.

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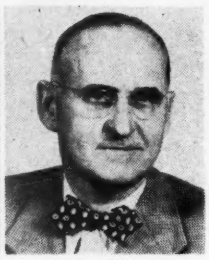
Roy R. Bush



M. D. Gilbert

Roy R. Bush has been named Tulsa, Oklahoma, district sales manager, and **M. D. Gilbert,** Kansas City district sales manager, Rockwell Manufacturing Company. Bush has been with Rockwell since 1934, and is a graduate of the University of Oklahoma. Gilbert, joined Pittsburgh Meter Company in 1924, and when the company merged with a Rockwell division he was assigned to the Houston district office. In 1944 he was promoted to Tulsa district sales manager, a position he held until his recent appointment.

John Duncan, Jr., has been appointed to the newly-created post of director of trade relations for the Kaylo Division of Owens-Illinois Glass Company. He will act as a special representative contacting major firms with which the company does business. Duncan has been with Owens-Illinois for the last 19 years and has served in sales, purchasing, and administrative capacities.

John Duncan, Jr.

Arthur H. Nelson has been appointed manager of electric tool sales in the Chicago, Illinois, branch of Independent Pneumatic Tool Company, manufacturers of Thor portable power tools. Nelson, long connected with automotive service industry sales, has been a Thor service engineer for the past several years.

Lee J. Laird, in addition to managing California sales, has been appointed assistant general sales manager of Baash-Ross Tool Company. In his new duties, Laird will not only cover the California area, but will also travel extensively throughout the Rocky Mountain, Mid-Continent, and Gulf Coast areas assisting E. M. Gearke, general sales manager.

Lee J. Laird

Mangum Webb has been elected vice president of Chemical Construction Corporation. He joined the firm in 1914 when it was founded, served as Far Eastern Representative in Shanghai, China from 1935 to 1936, as procurement director during World War II, then became assistant sales manager and director of engineering of the ion exchange department of American Cyanamid Company, the parent firm.

Gus M. Bagnard has been appointed chief engineer of Chiksan Company. He replaces Doyle C. Warren. Bagnard recently headed the engineering department's newly-created design and development division. Establishment of this division was necessitated by the increasing number of new products under consideration by the Chiksan Company.

Gus M. Bagnard

C. Ed Robertson has joined Green Contracting and Engineering Company as sales representative in Arkansas, Louisiana, and the Gulf Coast area of Texas.

Robertson is widely known in oil circles, having been affiliated with the supply business for a period of 30 years. He began his oil well supply career with Atlas Supply Company.

W. C. Gray has been appointed district manager of Great Lakes Corporation, distributors of Strata-Crete and Strata-Seal. "Dub" Gray comes to Great Lakes Corporation after having held positions as division manager of Security Engineering Company, Inc., in Canada and more recently as division manager of their operations in Oklahoma and Kansas.

W. C. Gray

V. J. (Bill) Scarola, who has been in charge of Tapecoat Company's New York office for the past seven years, has been appointed manager of sales with headquarters in Evanston, Illinois. Other appointees to serve with Scarola are **John G. Bolling,** manager of utility sales; **John Walsh,** manager of industrial sales; **Burt Schmidt,** mid-west sales and service; **Jack O'Brien,** western sales, with offices in Denver; and **Louis (Bob) Zito,** eastern sales, with offices in New York.

G. A. Dow J. H. Mackey O. G. Garner

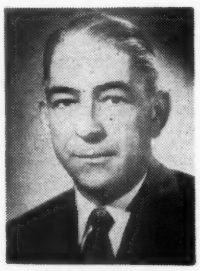
Glenn A. Dow, former division machinery manager for Mid-Continent Supply Company, at Tulsa, Oklahoma, has been transferred to sales engineer, New York City. Dow was first employed by Mid-Continent in 1947, in the purchasing department of the diesel division at Fort Worth, Texas. **J. H. Mackey** has been promoted from store manager at Abilene, Texas, to North Texas district manager for Mid-Continent. Mackey went to work for Mid-Continent Supply as field salesman at the Odessa, Texas, store in 1946. **O. G. Garner** has been promoted from field salesman at Williston, North Dakota, to store manager at the same location. Garner joined Mid-Continent in 1945, at the Wichita Falls, Texas, store.

Gordon G. Guiberson, until recently chairman of the executive committee of The Guiberson Corporation, was elected president of the company at a meeting of the Guiberson board of directors recently. In addition to his recent duties as chairman of the executive committee, Guiberson has in the past served the corporation as vice president and general manager and sales manager.

G. G. Guiberson

J. G. Lovett, Jr., has been named manager of The National Supply Company store at Odessa, Texas. He succeeds **Cecil P. Triplitt,** who recently was named assistant district manager at Odessa. A National Supply employee since 1943, Lovett was manager of the company stores at Imperial, Sundown, Fullerton, McCamey, and Kilgore, Texas, before being assigned to Odessa.

Hugh A. Crider has been named sales manager of The National Supply Company's southwest division. He succeeds R. L. Waller, who recently resigned. In his new assignment, Crider will supervise sales activities for National Supply's 20 stores in Northern Louisiana, Southern Arkansas, East Texas, North Texas, West Texas, New Mexico, and the Panhandle. Crider has been associated with National Supply since 1933.



H. A. Crider

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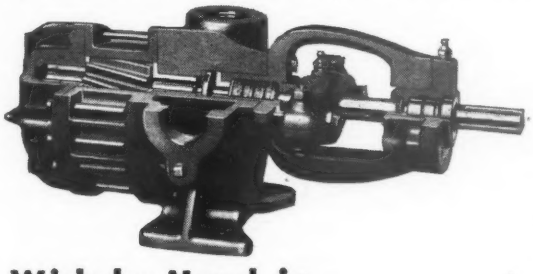

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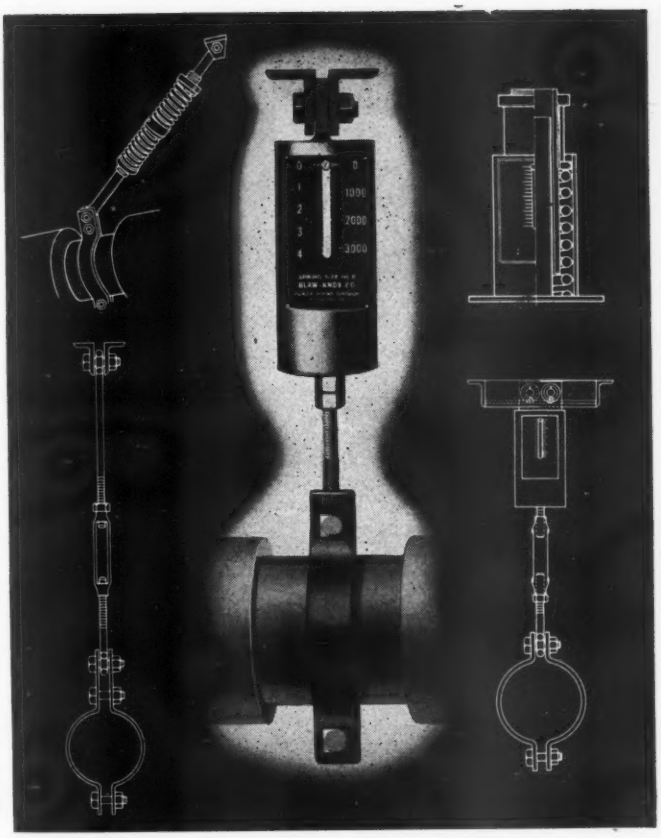

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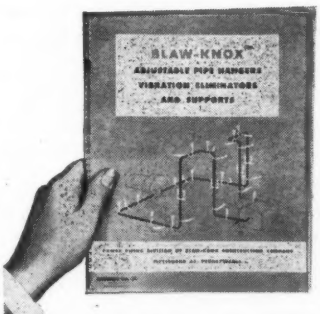

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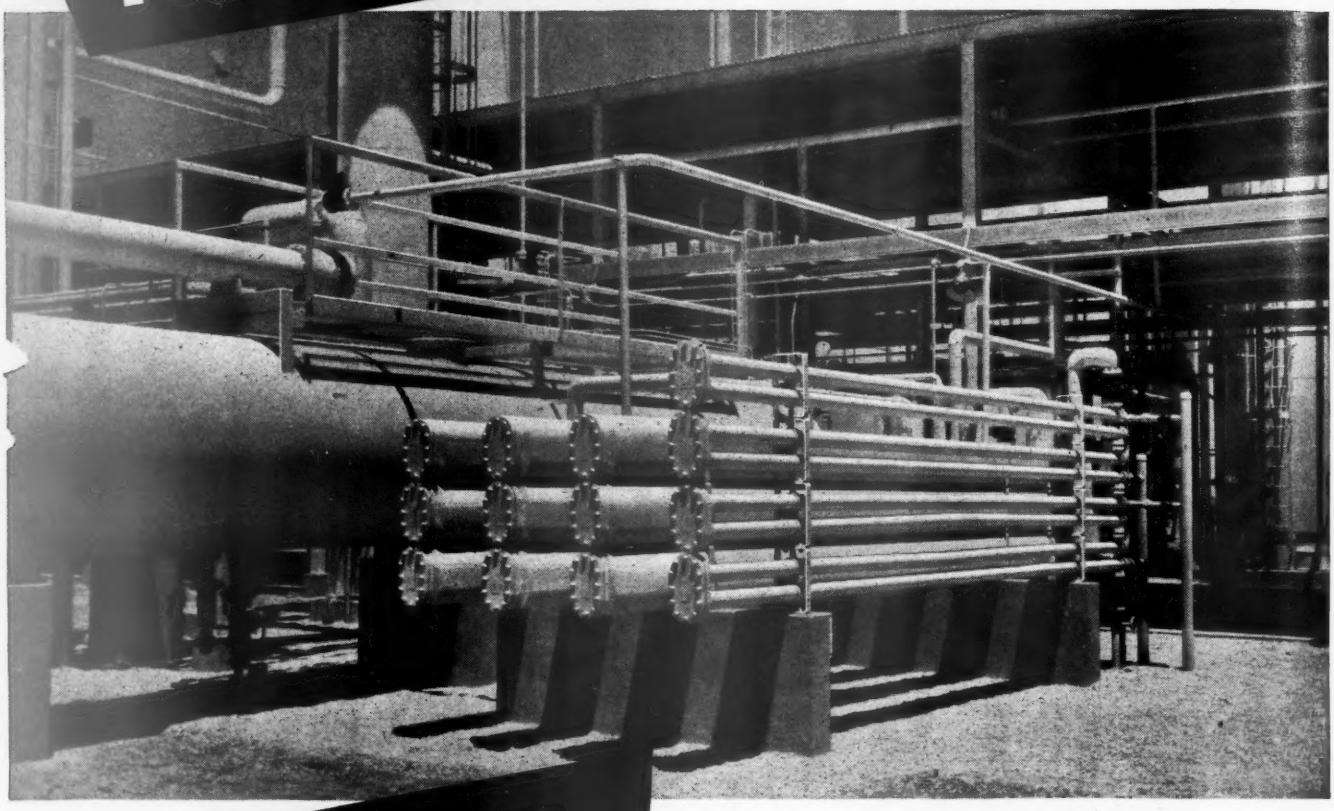

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L. L. Rector

J. P. Scott

J. L. Curry

G. M. Robinson

L. L. Rector, president, Rector Well Equipment Company, Inc., has just returned from a tour of the oil fields of South America. Sailing from New Orleans in mid-February, Rector arrived in Caracas late in the month, where he was joined by their South American representative, **W. C. Langley,** who accompanied him on a tour of the fields. **John P. Scott** has been named Rector sales representative at Hobbs, New Mexico. He is a graduate of Henderson State Teachers College, Arkadelphia, Arkansas. **G. M. Robinson,** has been named sales representative for Rector's West Texas division. He will have headquarters at Abilene, Texas.

Rector has announced the promotion of **John L. Curry** from manager of the company's Alice, Texas, district to manager of the Fulbore cementing equipment department. Curry will have his headquarters at the company's home office in Fort Worth.

Harold W. Sabin has been named sales representative for Toledo pipe tools in the area including Washington, Oregon, Montana, Idaho, Utah, Wyo-

H. W. Sabin

J. L. Emch

ming, and Vancouver and Victoria, B. C., Canada, for Toledo Pipe Threading Machine Company. He will make his headquarters in Seattle.

James L. Emch has been named sales representative for Toledo pipe tools in the area including Missouri, Kansas, Colorado, Nebraska, North Dakota, South Dakota, Iowa, and Cheyenne and Casper, Wyoming. Emch will make his headquarters in Kansas City.

John B. Poulton, formerly floorman at Continental Supply Company's Liberal, Kansas, store, has been promoted to manager at the same point. Former field salesman, **Ralph A. Broussard** at Houma, Louisiana, has also been named manager of the Houma store.

Will F. Sims has joined the staff of the Chemical Plants Division of Blaw-Knox Company with assignment to the Southwest office at Tulsa, Oklahoma. Sims has had an extensive background in petroleum processing and has been a member of the American Petroleum Institute for 25 years.

A. L. Jones has been appointed manager of the water treating division of Worthington Pump and Machinery Corporation. Formerly manager of the sale of water treating and deaerator section of the steam power division, Jones will now be in charge of sales, engineering, production, and service of water treating equipment for Worthington.

A. L. Jones

C. T. McGuire has been named division manager of Halliburton Oil Well Cementing Company's newly created Lubbock, Texas, division office. **J. L. Muse,** formerly of the Midland division, is assistant division manager.

Other transfers include: **W. L. Hughes,** transferred from Houston to Midland as assistant division manager of the Midland division; **Elmer Lawrence,** from Great Bend, Kansas, as assistant division manager of Evansville, Illinois, division; **A. O. White,** from Flora, Illinois, to Great Bend, Kansas, as assistant division manager of the Wichita division; **J. B. Jones,** from San Antonio to Houston, Texas, as contact man, and **W. A. Wallace** from Houston to Duncan as formation testing supervisor.

Edwin M. Miller has been appointed plant superintendent of the machine division for The Lincoln Electric Company. Miller has been with Lincoln for 29 years. He has been closely associated with the plant operations of Lincoln over an expansion period when the company was switching from motor manufacturing to becoming welding equipment manufacturers. He has been in the production control department since 1929 and has been head of that department for 10 years. His appointment followed resignation of H. F. Kneen, manufacturing vice president of Lincoln.

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for more power... less fuel... longer equipment life... reduced down time.

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TABLETS REMOVE AND PREVENT RUST AND SCALE IN ALL RADIATOR COOLING SYSTEMS
for economy and efficiency in Diesel Rigs and in trucks.
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F. L. LeBus, Sr.

F. L. LeBus, Jr.

J. S. Stammer

E. Burton

E. J. Calk

Frank L. LeBus, Sr., has been named chairman of the board, LeBus Rotary Tool Works, Inc. Other new officers include: **Frank L. LeBus, Jr.**, president and general plant manager; **John S. Stammer**, vice president; **Evans Burton**, secretary-treasurer and office manager, and **Earl J. Calk**, general manager sales and service. These officers were elected by the board of directors.

Walter T. Wells, chairman of the board of directors of Lane-Wells Company, has been awarded an honorary degree of Doctor of Science by West Coast University in recognition of distinguished service to advancement of engineering education. In recent years, Wells has filled a number of important educational positions for the state of California, and at present is a member of the State College Council for California State Polytechnic College.

Lake Brookbank was appointed manager of sales of the rig building department, Macco Corporation. He has been with the Macco Corporation for the past six years, five of which were spent in charge of rig building sales in the San

Lake Brookbank

J. D. Hawkins

Joaquin Valley. In 1951 he was brought to the home office and became a salesman in the Los Angeles Basin and other California areas.

J. D. Hawkins was appointed manager of sales of the drilling fluid division. Hawkins completed his education at U. S. C. in 1932. After leaving U. S. C. he was employed by Union Oil Company where he remained for 16 years.

J. G. McCray

H. E. Burtner

Jay G. McCray has been named general manager of Midwestern Engine and Equipment Company's branch office in Oklahoma City. McCray replaces T. E. Mitchell who reportedly resigned the post because of poor health. Mitchell, however, will remain partially active within the Midwestern Oklahoma City sales organization. McCray became shop superintendent at the Midwestern home office in Tulsa in 1948.

H. E. Burtner has been named to the sales force of Midwestern. He will handle the company's nationally-known lines of pipe line wrappings and supply materials. Burtner spent 13 years with the oil field division of the Gustin-Bacon Manufacturing Company. His specific responsibility at Midwestern will be in the sales and service of Fiberglas pipe wrap and allied products.

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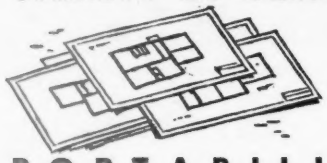
PREFABRICATED HOUSES

VARIETY OF DESIGNS . . .



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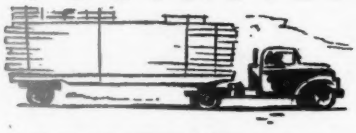

Complete housing sections moved anywhere a truck can go. Buildings erected on your site in days instead of weeks.

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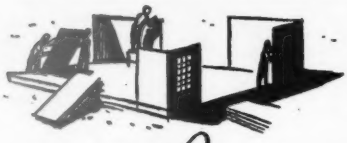

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STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD C5125 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

Paul Bowen, president of Bowen Fishing Tool Company, recently made a trip to Canada and completed arrangements for the United Drilling Services, Edmonton, Alberta, Canada, to maintain a rental stock of Bowen fishing tools and specialties and to handle sales of Bowen tool parts. **H. E. Snelson,** owner and manager of United Drilling Services, represents the S. R. Bowen Company in this area. He spent several years in Canada with Hughes Tool Company.

Donald E. Beaton has been named assistant general manager, hydraulic division, of Twin Disc Clutch Company. The new position occupied by Beaton was created as part of the over all expansion program of Twin Disc, including the current $1,500,000 expansion at the Rockford, Illinois plant. Beaton assumed responsibility February 1, under the division manager, integrating and coordinating all phases of manufacturing at the Rockford plant.

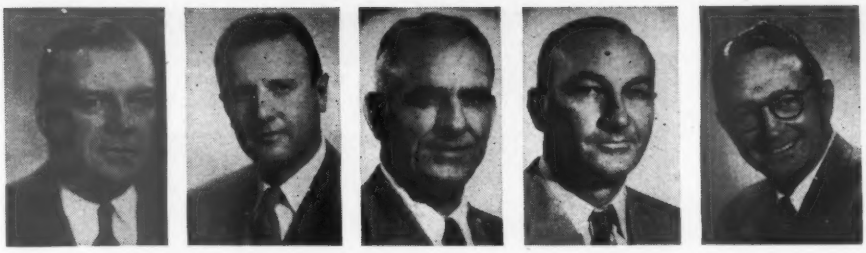
D. E. Beaton

J. L. Myers has been named assistant vice president and **Ralph E. Smith** has been made manager of the employe relations department of The Western Company. **Jack Benefield** has joined the staff of Western's employe relations department as editor of the employe publication, "The Western Brand." Myers has been with the company for a year and a half and was first a sales representative in the Panhandle-Western Kansas area with headquarters in Borger. Smith joined the staff of the employe relations department in November, 1951, as training supervisor. He formerly was training and personnel supervisor for the Shell Oil Company's Houston refinery. Benefield was oil editor for the Lubbock Avalanche-Journal before joining Western.

J. L. Myers

William C. Schneider has been appointed sales representative by Selas Corporation of America. His territory will include central and western New York state. His headquarters will be at Rochester, New York.

Ralph W. Malone, John A. Wilson, Ed C. Jones, and **Roy E. Hall** have been named vice presidents of Wyatt Metal and Boiler Works. Malone, general counsel for Wyatt as well as vice president, is a director of various other companies, and has been with Wyatt since 1929. Wilson, has been with the company since 1933. A graduate of Texas University, he was formerly with Mosher Steel Company. Hall joined the company in 1929 as a machinist and draftsman. Jones, who has been with Wyatt since 1923, served originally as a field superintendent and was later in charge of the building of the Houston shops. Another recent appointment in the promotion of **Jack C. Roberts** to assistant manager of sales. Roberts, who joined Wyatt in 1934, is a graduate of Texas A & M.



R. W. Malone J. A. Wilson E. C. Jones R. E. Hall J. C. Roberts

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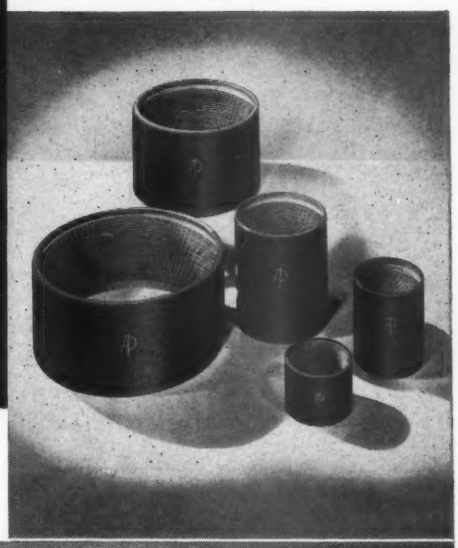
Harrisburg seamless steel pipe couplings . . . made to A.P.I. and A.I.S.I. specifications.



Harrisburg drop-forged steel pipe flanges . . . manufactured to A.S.A. standards.

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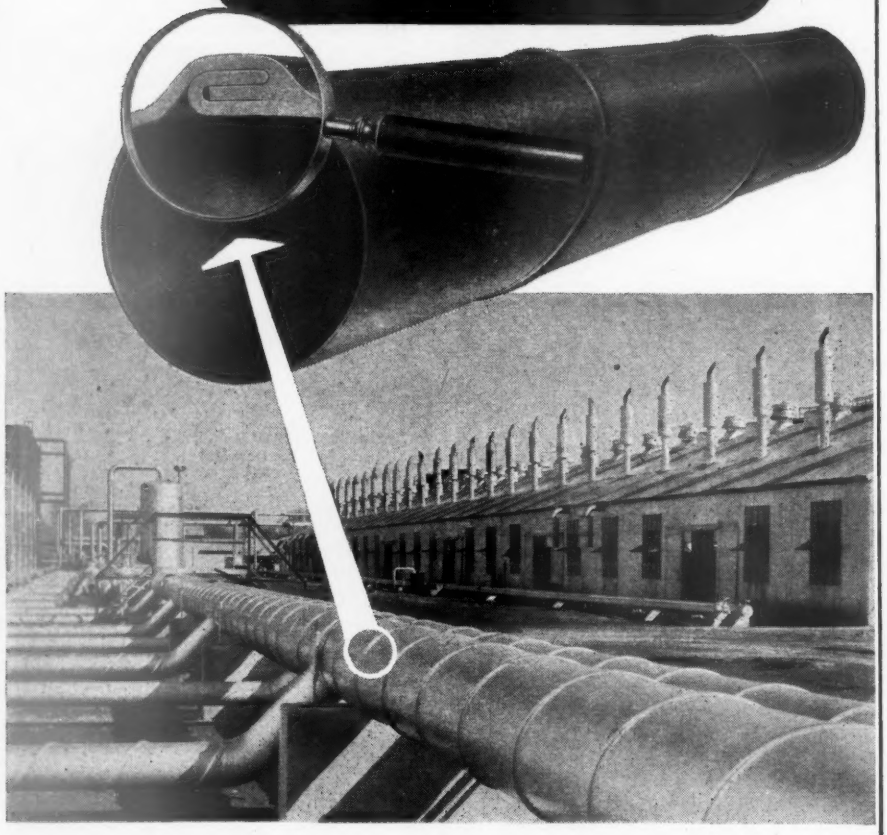
We shall be pleased to mail you copies of the Harrisburg Coupling and Flange Catalogs . . . and quote prices . . . upon request.

How NAYLOR gives you EXTRA STRENGTH in Light-weight Pipe



If you want to know why Naylor pipe out-performs other light-weight pipe in oil field service, here is just one of the reasons. If you could look inside Naylor's distinctive spiral, you would see the lockseam spiralweld structure which extends in spiral form throughout the length of the pipe. This spiralwelded truss provides greater structural strength—under pressure, compression, collapse, and beam load than any other iron or steel pipe of the same nominal wall thickness. That's why you can use Naylor Pipe on jobs normally requiring heavier-wall pipe. Write for Bulletin No. 507.

Naylor Pipe Company
1232 E. 92nd St., Chicago 19, Ill.
New York Office:
350 Madison Ave., New York 17, N.Y.

Mid-Continent Supply Company, **Ft. Worth, Texas and Branches**
Exclusive distributors in Mid-Continent and Gulf Coast Areas

▸ **W. N. Eason** has been promoted from shop foreman at Oklahoma City, Oklahoma, to service manager at the same location, for Cummins Sales and Service, Inc. Eason joined with Cummins in 1947 as a mechanic in Wichita Falls,

W. N. Eason | H. W. Everroad | J. T. Calnon

Texas. In 1950, he was transferred to Oklahoma City as shop foreman and has been in that capacity until his recent promotion. **H. W. Everroad** has been promoted from district service manager for Cummins at Oklahoma City, Oklahoma, to manager engine division at the same location. Everroad went to work for Cummins as field service mechanic at Wichita Falls in 1941. In 1950 he assumed new duties as district service manager at the Oklahoma City store. **J. T. Calnon** has been promoted from sales manager to vice president—sales for Cummins Sales & Service. Calnon's sales and service experience include work as district service manager at Houston and Wichita Falls, division service manager in Odessa, and sales manager in Fort Worth.

▸ **C. P. (Smiles) Gillespie** is new district manager for sales of Beaumont Iron Works drilling and producing equipment in Louisiana, Mississippi, and Arkansas. His headquarters are in Houma, Louisiana. Gillespie has had more than 35 years experience in the oil business.

C. P. Gillespie

He has been associated both with major oil companies and with equipment manufacturers.

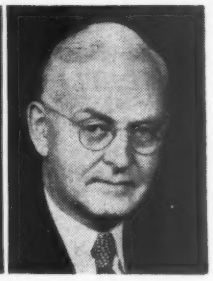
▸ **W. A. Glimn** has been appointed director of purchases for Gar Wood Industries, succeeding C. M. "Red" Strong who died recently. Glimn has been with the corporation since 1948 when he took over the job of purchasing agent at Gar Wood's Findlay division at Findlay, Ohio.

According to an announcement received from E. R. Leeder, executive vice president, Gar Wood Industries, **W. C. Robertson,** formerly vice president — export, has been named vice president in charge of government sales and regulations.

E. B. Hill, formerly vice president in charge of domestic sales, becomes vice president—domestic and export sales. Export headquarters, until now in New York, will be in Wayne, Michigan.

W. J. Sparling has been appointed to the newly created position of vice president and manager of Milwaukee, Wisconsin operations of Chain Belt Company of Milwaukee. He will have executive responsibility for the three major Milwaukee divisions, construction machinery, chain and power transmission, and conveyor and process equipment. He joined the company as a student engineer in 1928.

W. J. Sparling



M. G. Jewett

M. G. Jewett has been appointed manager, chain and power transmission division. A graduate of Michigan State, he joined Chain Belt Company in 1927 as a research engineer. **B. F. Devine,** vice president and manager of the construction machinery division, will become a staff officer of the company and serve it in an advisory and consulting capacity.

A. K. Thomas has been appointed manager, construction machinery division. He joined Chain Belt in 1940. **W. A. Clayton** has been made sales manager, construction machinery division. He joined Chain Belt Company in 1948. **J. W. Lendved,** who has been appointed director of engineering, construction machinery division, joined the company in 1936 as a student engineer. **W. C. Messinger,** who is, at present, manager of Chain Belt Company's Ordnance division, was elected as assistant secretary of the company by the board of directors at its annual meeting.

A. D. (Doyle) Tucker has been named to the staff of the West Texas division of Technical Oil Tool Corporation, Los Angeles. He will service Totco customers in the Snyder and San Angelo, Texas, area. Working directly under F. E. Siever, West Texas division manager, Tucker will handle the territory covered by the Continental Supply Company stores in Snyder and San Angelo, Texas.

L. O. Gore has been promoted to sales manager of The Western Company's Panhandle - Western Kansas district. **Wallace McBrayer** has been transferred to that district as a sales representative. In his new position, Gore will maintain his office at the company's district headquarters in Borger. He has been with the company since its organization in 1939. McBrayer's office is in Ulysses, Kansas in connection with Western's field station there. A graduate of Texas Tech College, McBrayer has been with the company six months.

M. E. (Mike) Hunter has been named manager of the Southwest Texas district with headquarters at Corpus Christi, for Oil Center Tool Company. An employee of O-C-T since 1937, he was stationed in Victoria before being transferred to Corpus Christi. **Myles G. Esterak** has recently joined the O-C-T organization and is a sales representative in the Southwest Texas district with headquarters in Victoria. Before joining O-C-T, he was associated for several years with Republic Supply Company.

M. E. Hunter

M. G. Esterak

H. M. Reeser, vice president and secretary, and **D. M. Horner,** vice president, have been elected to the board of directors of the Harrisburg Steel Corporation. Reeser, whose primary responsibility is sales, has been associated with the corporation for 34 years. Horner, in charge of engineering and operations, has been employed by Harrisburg Steel for 24 years.

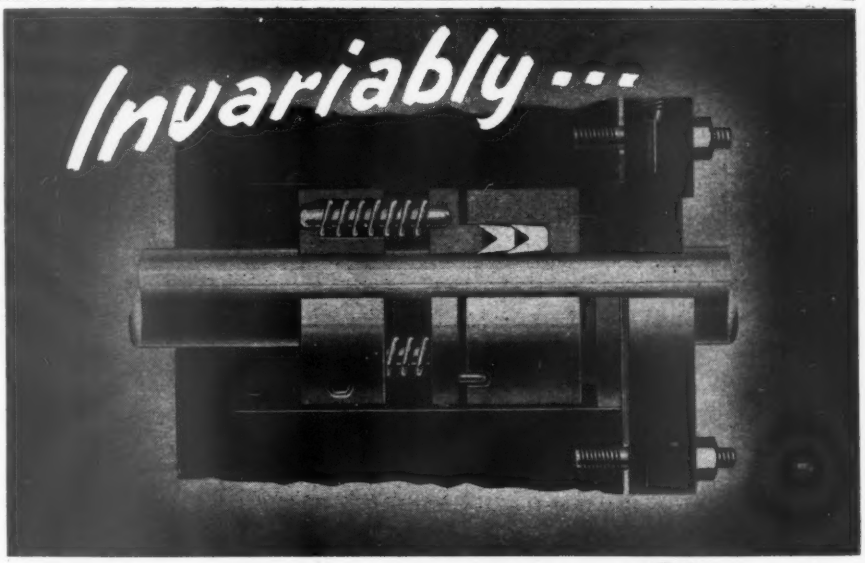
ARMSTRONG BROS.
Better PIPE TOOLS

CHAIN TONGS

"Reversible," "Standard" and "Ideal" types in all sizes. Jaws are drop forged from special steel, are carefully milled, heat treated, hardened and tested. The *Handles* are forged spring steel. The *Chains* are proof-tested to ⅔ catalog strength (1,200 lb. to 40,000 lb.). "Reversible" Jaws give double jaw life. "Standard" Jaws have extra bearing on the handle and forged-in chain guides. The "Ideal" Tongs have V shaped teeth for a sure grip on irregular shapes—fittings, etc.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
5231 W. ARMSTRONG AVENUE • CHICAGO 30, ILL.



...invariably it's DURA SEAL
The PERFECT SEAL
ROTATES WITH THE SHAFT
for long dependable service

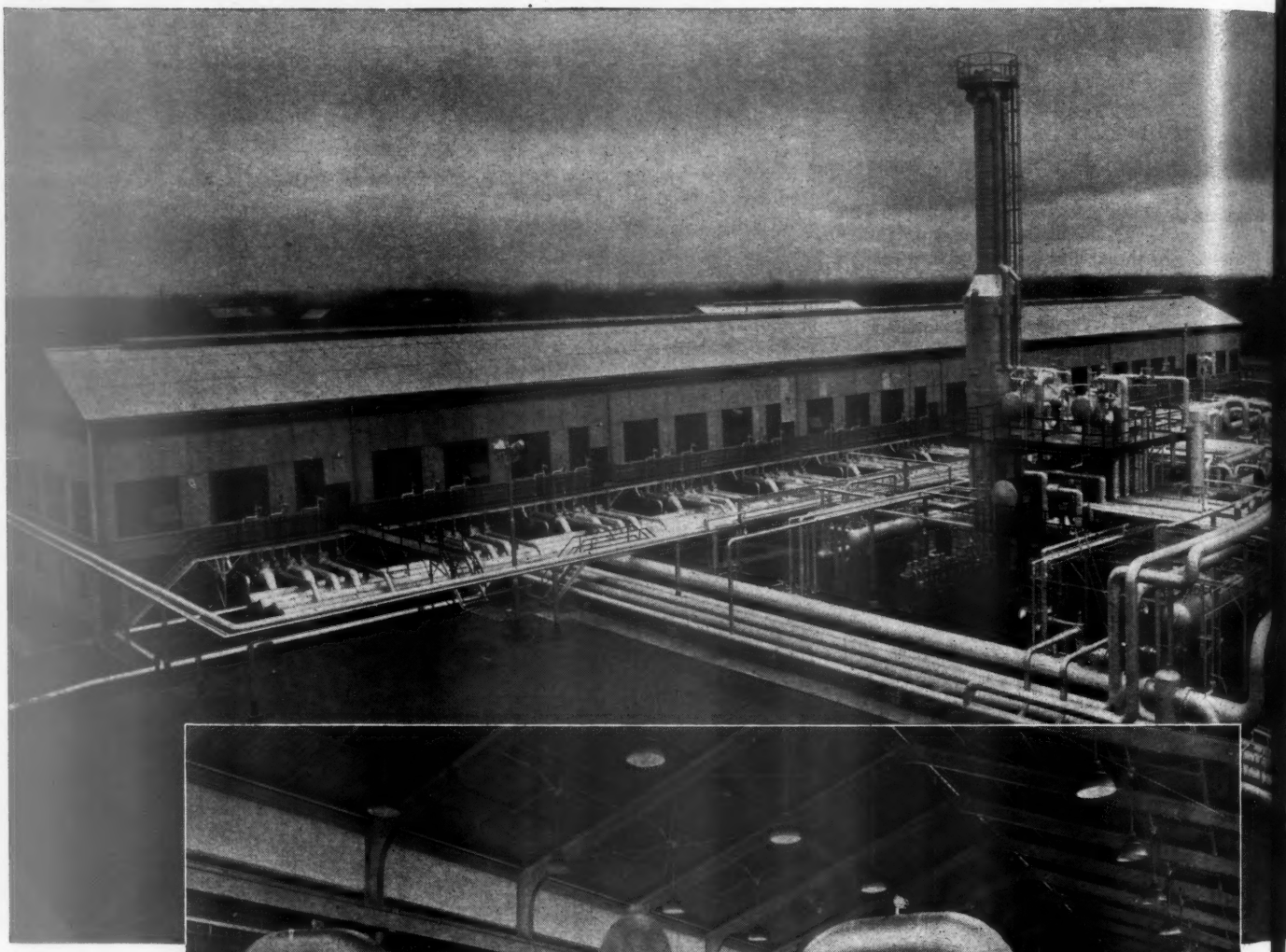
WHERE
....ECONOMICAL OPERATION IS DESIRED
....OPERATING CONDITIONS ARE HAZARDOUS
....LOSS OF COSTLY FLUIDS MUST BE PREVENTED
....COMPLETE AND PERFECT SEALING REQUIRED

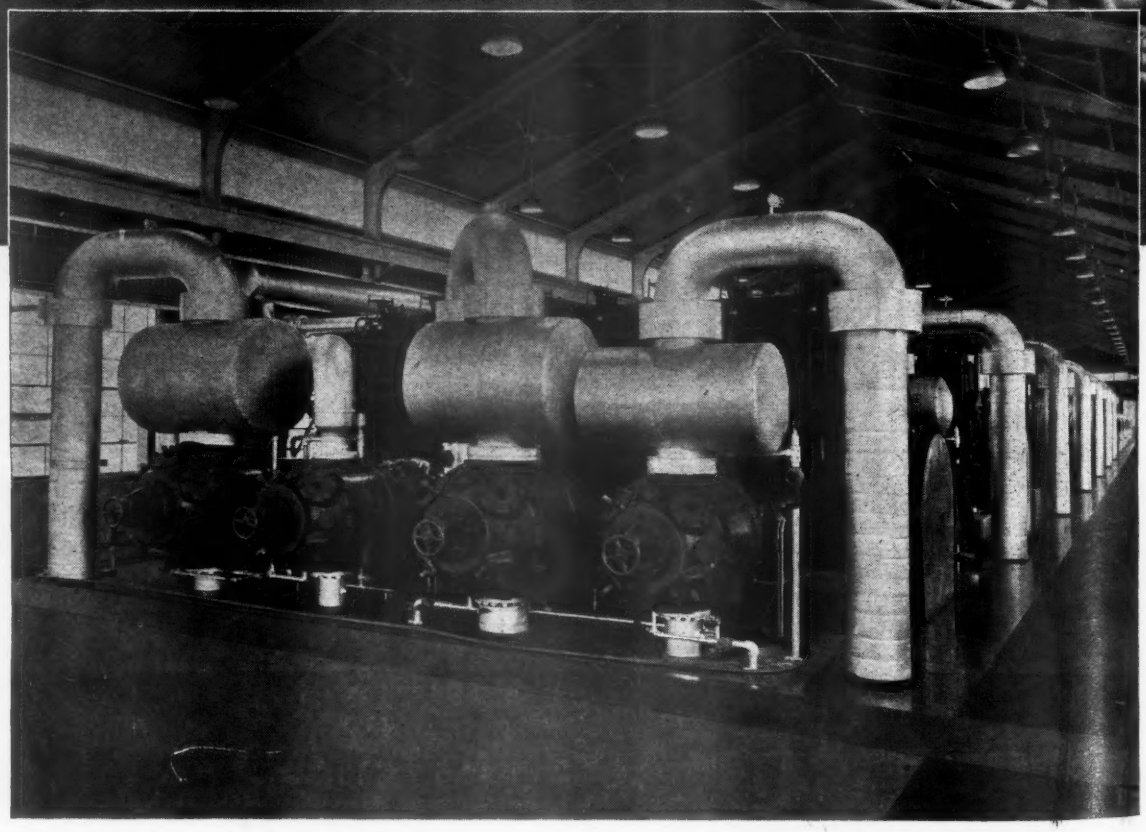
GET THE "DURA SEAL" STORY—WRITE FOR BULLETIN 174PE

DURAMETALLIC CORPORATION
The PERFECT SEAL
KALAMAZOO MICHIGAN

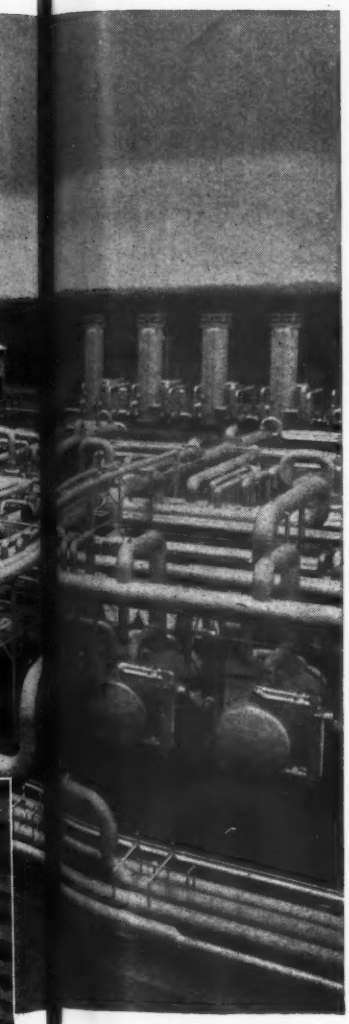
To obtain more information on products advertised see page E-49

Clark "Big Angles"





score another first!



Clark HBA Compressors, Famed for Sustained Fuel Economy and Dependability, Installed in World's Largest Ethane Recovery Plant

Tennessee Gas Transmission Company recently placed in service the largest ethane recovery plant ever built for operation in conjunction with a gas transmission pipeline. In designing the Gabe, Kentucky plant, process requirements dictated the following rigid compressor specifications:

- A total of 23,000 horsepower required
- 1600 to 1800 horsepower units were necessary for proper compressor distribution between the five compression services
- 750,000,000 cubic feet per day capacity
- Four compressor cylinders per unit
- Minimum fuel consumption was necessary because overall economics indicated an "end of the line" high fuel cost, plant location

With over 135,000 horsepower of Clark BA and HBA compressors already operating in their other compressor stations or on order, Tennessee Gas Transmission Co. knew first hand what the "Big Angle" could do. Thirteen Clark 1760 BHP, High Compression "Big Angles" were subsequently installed to handle all compression services in the new plant. These services include propane refrigeration, ethane refrigeration, reactivating gas service, flash gas service and the return of residue gas to the pipeline.

If you are contemplating building a plant involving intricate processing operations, consult your nearest Clark representative. He has the compressor know-how and a complete line of heavy duty compressor equipment to simplify your installation.

For complete details on Clark Big Angles request Bulletin 104

CLARK BROS. CO., INC. • OLEAN, N. Y.

One of the Dresser Industries

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

There's a BIG difference in...

CLARK® compressors

J. C. Norton

C. T. Jones

Frank Smith

Red Kluck

B. G. Barefield

William Delaney

C. T. Jones, former salesman in the West Texas district, has been named district manager of the West Texas district for Oil Center Tool Company. **Frank Smith**, former salesman in the West Texas area, has been named assistant West Texas manager and will be in direct charge of the Farmington, New Mexico, district. **J. C. Norton**, formerly in the Alice, Texas, area for Oil Center Tool, has been transferred to Dallas and will be the new district manager for the North Texas and Oklahoma area.

Red Kluck, formerly employed by Spiars Well Equipment Company and LeBus Rotary Tools, has joined the O-C-T organization as a salesman in the West Texas area.

B. G. (Bill) Barefield has been transferred from Houston to the expanded O-C-T facilities in the Midland-Odessa area where he will be chief warehouseman for the West Texas store.

William Delaney, who has just completed a three months training program in the Houston shops and office, has been sent to Odessa as a serviceman.

C. K. Hood has been elected to a vice presidency of Worthington Pump and Machinery Corporation. He will be responsible for the direction of the activities of the public works, steam power, deaerating, water treating, and steam turbine divisions and will report to T. Cruthers, vice president.

C. K. Hood

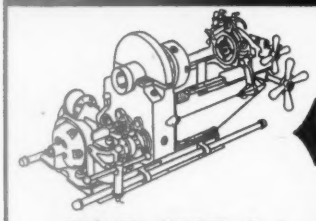
Hood, a graduate of Iowa State College, began his career with Worthington in 1918 and has been manager of the New York district sales office since 1930.

Donald W. Bedell has been appointed industrial relations assistant to L. C. Ricketts, vice president in charge of manufacturing of Worthington Pump and Machinery Corporation.

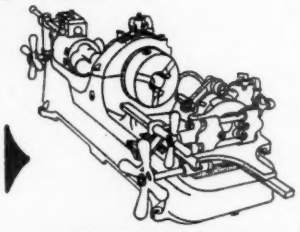
Morris S. Palmer has been named manager of field sales for Manning, Maxwell & Moore, Inc. **Raymond F. Attner** replaces Palmer as Hancock valves product manager. Previously a salesman in several territories and district manager in Chicago, Palmer joined the company in 1922. Attner, also with 30 years of service with the company, was formerly distributor-manager of valves.

Thomas I. Brown, Jr., has joined the sales staff of Nelson Electric Manufacturing Company, Tulsa, Oklahoma. He will serve as a sales engineer in the Tulsa area. A University of Oklahoma graduate, Brown was previously employed by Minneapolis-Honeywell Regulator Company.

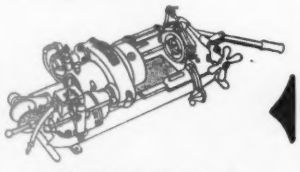
BEAVER—gives you a choice of 4 PIPE and BOLT MACHINES



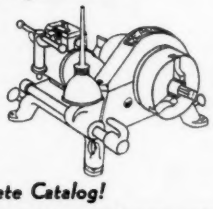
BEAVER MODEL-A
A rugged, Heavy-Duty Machine. Range ⅛ to 2". Up to 12" with Geared Tools and Drive Shaft. Bolts ¼ to 2"—Weight 365 lbs.



BEAVER MODEL-B
A Middleweight Utility Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 235 lbs.



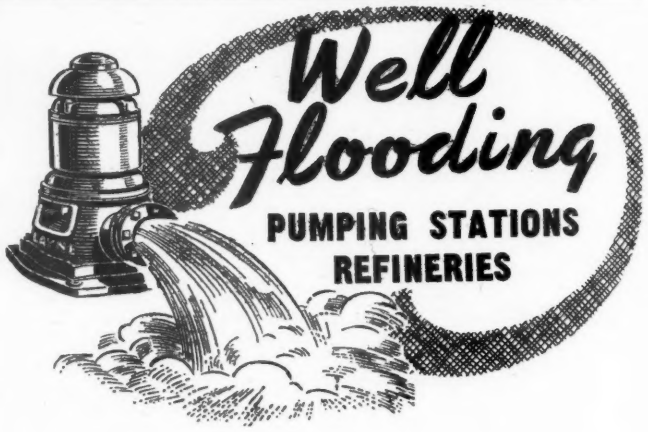
BEAVER MODEL-E
A Lightweight Portable Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 185 lbs.



BEAVER MODEL-CI
A sturdy little Power Drive that converts Hand Tools into Power Tools—Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 140 lbs.

Write for NEW Complete Catalog!

BEAVER PIPE TOOLS, 256-300 DANA AVE., WARREN, OHIO



Layne built well water supply units of extra heavy capacity offer a quick, efficient and modern method of well flooding to increase oil recovery. Installations in single or multiple units are easily controlled for normal or pressure flooding. Layne also makes installations for pipeline pumping stations, cooling and general purpose water for refineries, office air conditioning, fire protection and employee housing needs. All installations are made by Layne's own field crews. Complete information, catalogs, bulletins, etc., will be sent on request. Address

LAYNE & BOWLER, INC.
General Offices, Memphis 8, Tenn.

Layne WATER SUPPLY WELLS & PUMPS

J. H. Sheusner

L. O. Mjolsnes

John H. Sheusner, formerly chief engineer of Enterprise Engine and Machinery Company, has been named manager of engineering and manufacturing. In his enlarged activities Sheusner will retain his former interest in all development phases.

Leonard O. Mjolsnes is the new chief engineer of Enterprise Engine and Machinery. Mjolsnes has spent many years in design and development work on diesel engines.

This West Coast manufacturing division of General Metals Corporation also announced new sales personnel in the diesel engine division: **Ray Hogaboom,** new district manager of the Los Angeles branch, with **Charles Carmichael,** sales engineer, added to the branch office staff in Chicago. **Dennis J. O'Leary** and **Stuart F. Atsatt** are new sales engineers serving the industry from the San Francisco office.

Albert M. "Bert" Birnie has recently joined Welex Jet Services, Inc., as general sales manager. He is responsible for the overall supervision of Welex sales activities. Birnie was regional manager with Security Engineering Company for seven years before joining Welex Jet, and will work closely with the company's 3 division managers and 10 district managers. His office is in Fort Worth.

A. M. Birnie

Welex has recently expanded its services to the oil industry through the addition of radioactivity well logging services, now offered on the Gulf Coast.

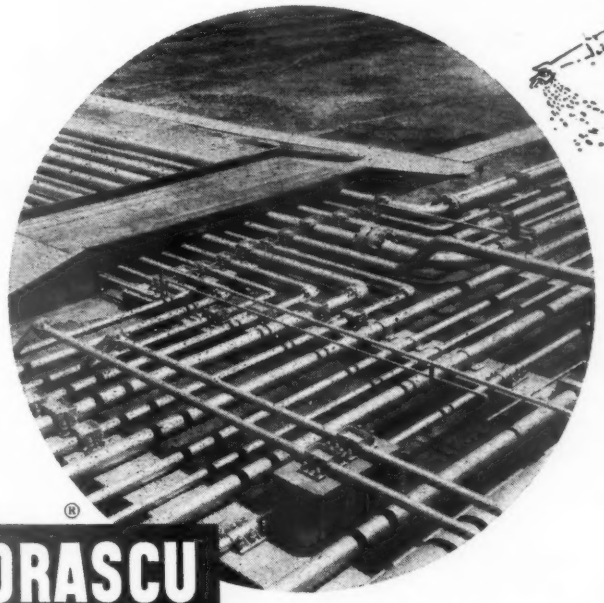
Raymond J. Lawn has been named supervisor of synthetic coatings research for Pittsburgh Coke and Chemical Company. In this capacity, he will be responsible for the supervision and coordination of the company's research and development activities as well as laboratory technical service on synthetic corrosion resistant industrial coatings. Prior to joining Pittsburgh Coke, Lawn was with the United Wallpaper Corporation.

R. J. Lawn

Edward L. Fish and **Robert B. Crawford** were named national sales representatives of the Drill Bit and Tool Company. With headquarters at the Midland plant, they are responsible for the marketing of the company's Midland Throwaway forged steel rock bits throughout the mining, quarry, construction, and other heavy industries. Fish joined Drill Bit and Tool from the Pittsburgh sales office of the Chicago Pneumatic Tool Company. He is a graduate mining engineer and a former mechanical mining engineer for the U. S. Bureau of Mines. Crawford was for five years a sales representative in northern West Virginia and eastern Ohio for Beckwith Machinery Company, Pittsburgh.

Robert F. Gregg has been named district manager of tubular sales by Continental Supply Company. He goes to his new position from that of city salesman at Midland, Texas, and in various capacities at other store points. Also announced is appointment of **Ralph A. Broussard** as manager of the Houma, Louisiana, store under the direct supervision of Raleigh Hortensteine, Jr., assistant district manager, New Iberia.

R. F. Gregg



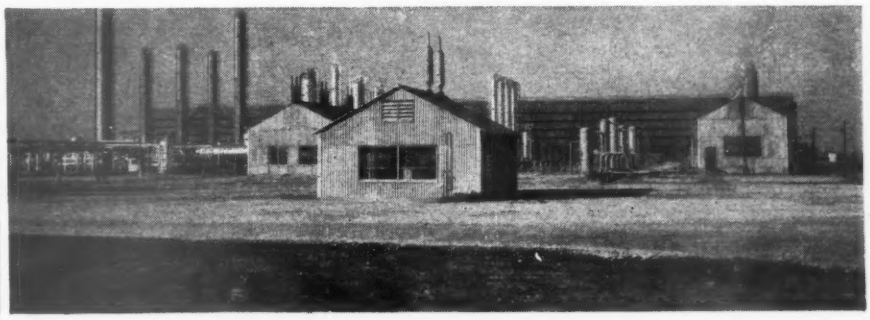
BORASCU
WEED KILLER

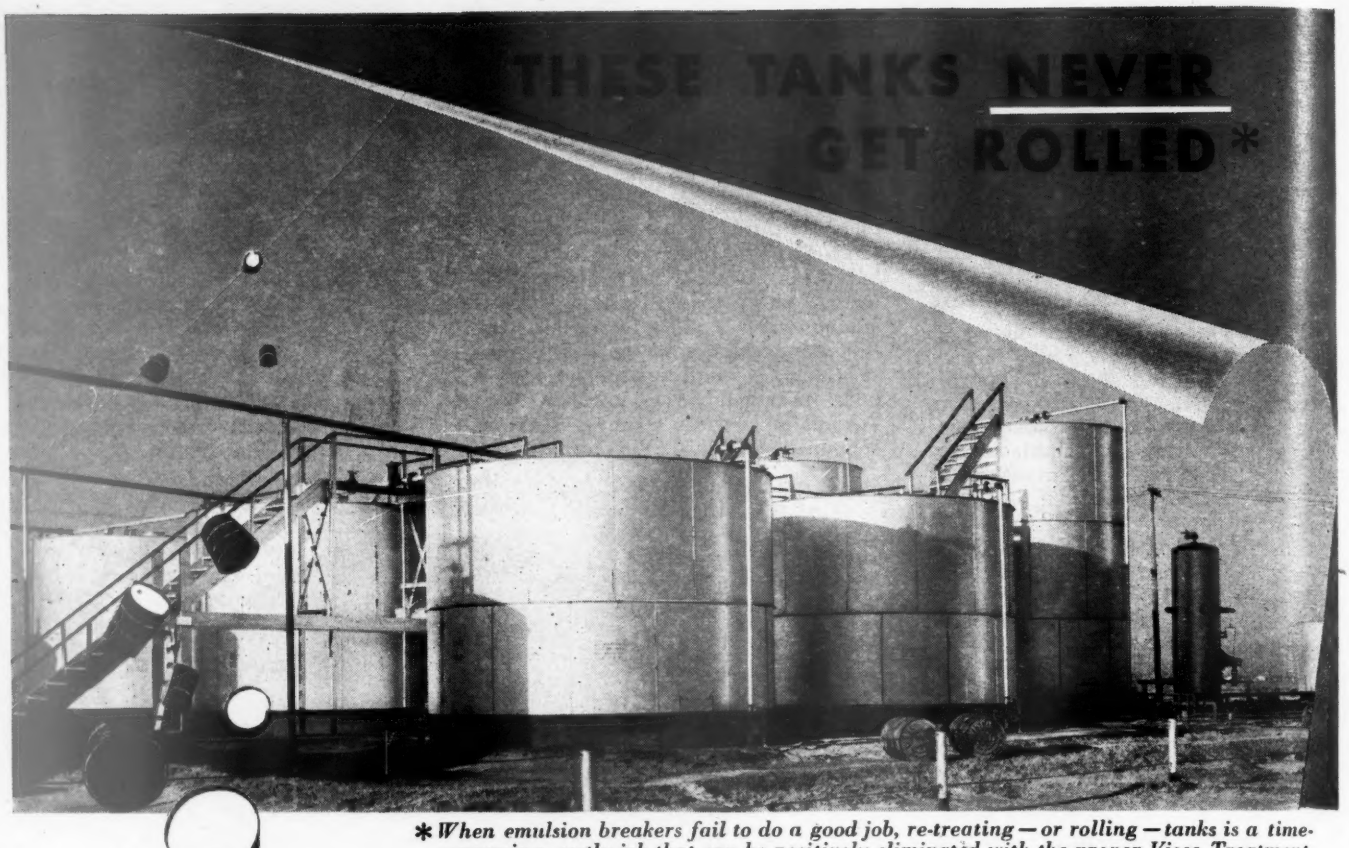
NONCORROSIVE*• NONPOISONOUS
*To Ferrous Metals
NONFLAMMABLE • NONSELECTIVE

WRITE FOR LITERATURE

Removal of weeds and grasses need not be a costly problem! Borascu, when properly applied, will destroy weeds and grasses with its effective root-action; yet it is safe, inexpensive and easy to use. Removing undesirable vegetation by old-fashioned methods such as hoeing monthly, or quarterly, is an extravagant waste of manpower and money. Be thrifty ...use Borascu; a single application may keep an area cleared for 18 to 24 months!

PACIFIC COAST BORAX CO.
DIVISION OF BORAX CONSOLIDATED, LIMITED
630 SHATTO PLACE • LOS ANGELES 5, CALIFORNIA
DISTRIBUTORS LOCATED THROUGHOUT THE OIL FIELDS OF U. S. A. AND CANADA





**When emulsion breakers fail to do a good job, re-treating — or rolling — tanks is a time-consuming, costly job that can be positively eliminated with the proper Visco Treatment.*

Oil on this lease is *Visco* TREATED

Put your lease into the picture above . . . It can be the same story with *your* oil and Visco Emulsion Breakers, aimed at consistently producing dry oil at lowest treatment cost per barrel.

Call Houston, Capitol 7300, collect, for fast action by competent Visco Field Service.

VISCO VS SOLVENT
New, high-flash-point solvent for wax, grease, paint, oil-treating chemicals, and fusible or soft resins. Safe to use on skin, metal or wood. Available now in 5-gallon cans and 55-gallon drums. Write or call for full details and prices.

VISCO PRODUCTS COMPANY
INCORPORATED
City National Bank Building
Houston 2, Texas

***Visco*... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS**

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating Compounds for use in the breaking and resolving of oil emulsions, or to grant licenses for such use, under the following United States Letters Patent: 2,050,639; 2,050,640; 2,206,589; 2,214,783; 2,214,784; 2,225,189; 2,303,414; 2,307,813; 2,318,034; 2,318,035; 2,321,056; 2,335,554; 2,454,808; 2,514,399. Visco Products Company is willing to grant licenses on a royalty basis, to oil companies, and to others desiring to practice the patented subject matter, under any and all of the above Letters Patent, permitting the user to purchase the oil treating compounds at will from any vendor, or to prepare the compounds for use or to use the compounds under the above Letters Patent. Application for license should be made to: **Visco Products Company,** Houston, Texas.

New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card.

(A) POWER UNIT

A new precision 60-cycle power supply unit has been announced by Ampex Electric Corporation. According to the company this unit, known as Model 375, provides accurate frequency stabilization for operating laboratory and test equipment. The frequency stability claimed is five part per million per degree Centigrade. It provides 60 watts of power. Input may vary from 50 to 400 cycles and from 90 to 125 v. Output is constant at 60-cycles and adjustable from 0 to 150 v. It is designed for standard rack mounting.

Circle letter (A) on reply card.

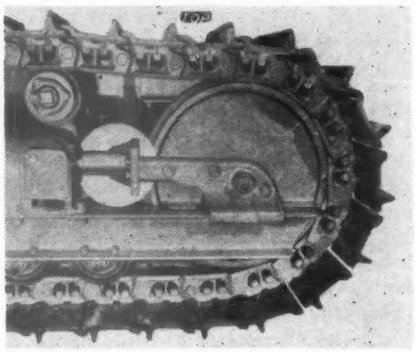
(B) PLASTIC PIPE

A complete range of flexible and rigid plastic pipe for every piping need is now being manufactured by The Plastex Pipe and Extrusion Company. The firm has been engaged in the custom extrusion of plastics since 1939 and will continue to carry on this business in addition to making plastic pipe. The new product known as Plastex corrosion proof pipe is extremely light weight, weighing about one-tenth that of equivalent metal pipe. Installations above or below ground are quickly accomplished without special tools and connections are easily made with cemented plastic fittings. Plastex pipe comes in a complete range of standard pipe sizes from ½ up to 6 in.

Circle letter (B) on reply card.

(C) TRACK ADJUSTER

The Hydradjuster is a patented hydraulic track adjuster available for all models of Allis-Chalmers, Caterpillar, and International crawler tractors. A few shots from a standard grease gun



takes up the slack in the track, thereby eliminating the laborious time-consuming task of manually adjusting the track with adjusting screw and nut. The Hydradjuster was designed and developed in 1949 and has been field tested, with over 500 installations, during the last year and a half. The manufacturer states, due to ease of adjusting tracks, the operator will keep the tracks of his crawler tractor adjusted properly. This eliminates unnecessary wear on rails, idlers, rollers, sprockets, and other mechanical parts. Installation of the Hydradjuster can be made in the field.

Circle letter (C) on reply card.

(D) FEED PACKAGED UNIT

A new chemical feed packaged unit, which delivers liquids in desired amounts under pressure, has been announced by The Bird-Archer Company. This unit is suited for feeding boiler water treatment as well as delivering chemicals and other fluids for processing. The chemical reservoir tank is of welded steel construction, available in 50 or 100-gal capacity. The chemical proportioning pump can be designed for various rates of feed at different pressures. A specially designed agitator assures completely mixed fluids.

Circle letter (D) on reply card.

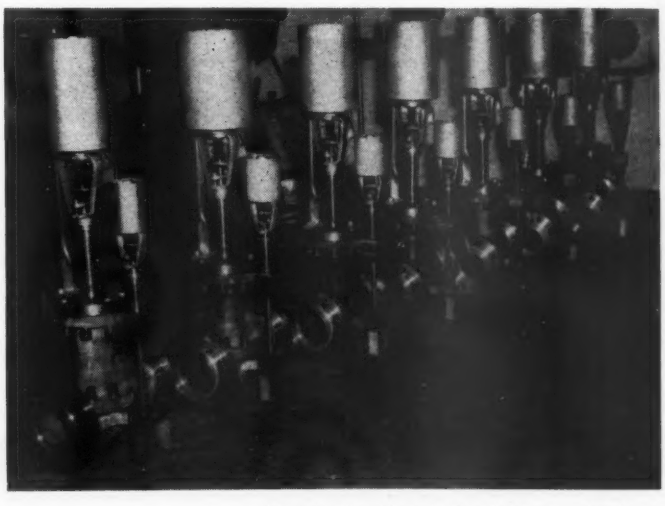
(E) CONTROL VALVES

Two new control valves, Models 1570 and 1580, announced by the Annin Company, are capable of handling a wide variety of materials at extremes of temperature and pressure, the manufacturer claims. These include liquid nitrogen at a temperature of -325 F and a pressure up to 3000 psi, red fuming nitric acid at room temperatures and superheated steam up to 1000 F.

Unique design feature of these single seated valves is the external self-balancing arrangement that provides a balanced valve effect in operation. This feature provides ease of operation at extreme pressure differentials and still retains the positive bubble-tight shutoff essential in so many applications.

Circle letter (E) on reply card.

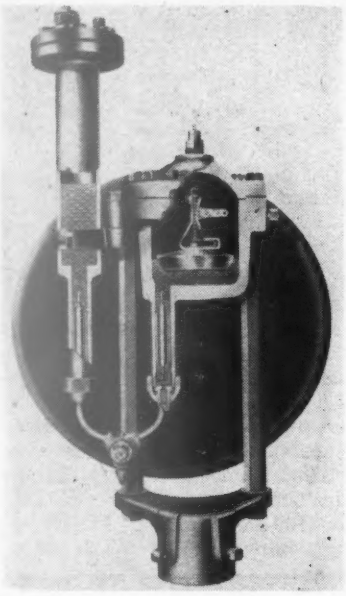
Plastic pipe made by the Plastex Pipe and Extrusion.



Newly developed Annin control valves.

(F) FLOW METERS

The Foxboro Company has announced five basic improvements in its flow meters. First is the pressure seal bearing, lubricated at the factory to eliminate periodic lubrication maintenance. The plastic check floats are interchangeable and kept clean by complete submersion in mercury. A new stainless steel ball-plug and seat prevents clogging and locking. The improved U-Bend has metal-to-metal compression seals, tested at 10,000 psi for full protection against mercury loss. The new damping plug is calibrated to simplify damping adjustments. Finally, a new type of stainless steel ball-chain, by which the powerful straight-line motion of the float is transmitted to the recording pen assembly, eliminates friction and errors of angularity.



Circle letter (F) on reply card.

(G) WATER TREATMENT

Heller Laboratories has developed a new water treatment process and equipment called "Hydrotron," which it claims eliminates scale in heat exchange equipment by changing water electrophysically. This results in the crystallizing out of the minerals contained in the water in the form of a sludge or slurry and thereby do not form a dense hard coating over heat exchange surfaces. The sludge formed can be removed by the usual methods of blowdown. This process is said to eliminate the need for a water softener or chemicals for the control of hard water scale.

Circle letter (G) on reply card.

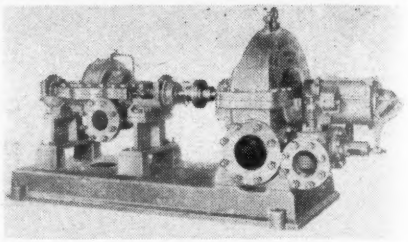
(H) VARIABLE SPEED DRIVE

A variable speed drive with mounting dimensions that are interchangeable with NEMA standard motors has been announced by Sterling Electric Motors, Inc. This new drive consists of a variable speed transmission with positively adjusted pulleys and an induction motor built in a single, compact unit.

Circle letter (H) on reply card.

(I) TURBINE LINE

The Dean Hill Pump Company has recently announced a horsepower step up in its DH line of steam turbines. Formerly these turbines developed 500 hp with pressures up to 600 psi at 700 F. Now, with the horsepower increase, DH turbines are capable of developing 1000 hp with pressures up to 875 psi at 750 F. DH steam turbines are single stage impulse, double impact type. Steam is directed twice against a singe row of blades by use of special steam-reversing nozzles, thus giving double impact to the rotor and converting energy within the steam into work.



Circle letter (I) on reply card.

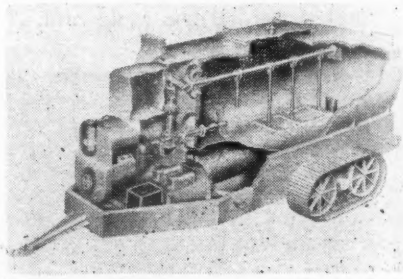
(J) ELECTRONIC TONES

An electronic "ear," deaf to all but a single electronic tone, or combination of tones, has been described by a General Electric communications man, Charles L. Rouault. He said the device has led to development of a new line of products, which add privacy to mobile radio systems, and which greatly speed pushbutton remote control operations. Connected to a special switch, the sensitive listener is capable of turning on and off any kind of electrical apparatus, from radio receivers and transmitters to electric motors, which can perform numerous functions.

Circle letter (J) on reply card.

(K) DOPE KETTLE

A new type dope kettle has been placed on the market by Crutcher-Rolfs-Cummings, Inc. Known as the Model "SP," this kettle features double agitation among several other new improvements. Agitation is accomplished by a marine type propeller plus a slow speed bottom sweep. Another great improvement is in the combustion chamber which has a double gas pass for bottom protection and fuel economy. The particular construction used in the kettle, the company reports, allows it to utilize the highest possible amount of heat from the gases burned. Insulation is provided by a 2-in. thickness of rock wool over all exposed surfaces.



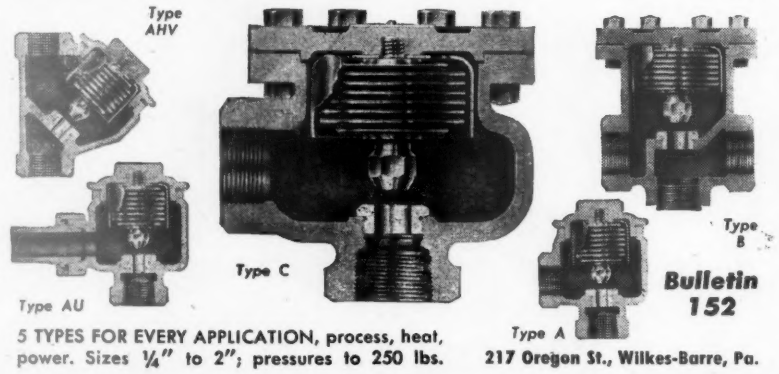
Circle letter (K) on reply card.

In This Plant Nicholson Traps

SAVED 10% IN STEAM COSTS

Chief Engineer H.F.D. stated, after Nicholsons replaced mechanical traps in his plant: "Saving in steam waste cut our fuel cost at least 10%. Yet application temperatures were up 30°-40°. And relief of all air binding effected faster warm-up."

Operate on lowest temperature differential; 2 to 6 times average drainage capacity; maximum air venting. For other advanced Nicholson features send for Bulletin 152.



Bulletin 152

5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; pressures to 250 lbs.

217 Oregon St., Wilkes-Barre, Pa.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

Burgess-Manning noise controller.

(L) NOISE SILENCER

Picture above shows the range of industrial acoustical devices made by Burgess-Manning Company, to silence the roar of exhaust from internal combustion engine. Big fellow is an STC-30, weighs 9000 lb, has a diameter of 72 in. and is 318 in. long. Little Snubber is an STC-1, weighs 6 lb, is 4½ in. in diameter and 22 in. long. These Snubbers are designed to prevent rather than to muffle exhaust noise.

Circle letter (L) on reply card.

(M) TRENCHLINER

A new, mobile, rubber tired, ladder type trenchliner that will handle all types of utility excavations has been announced by the Parsons Company. This Model 88 Trenchmobile digs to a maximum depth of 5 ft and widths of 8 or

12 in. Powered by a 43.6 hp gasoline engine, the Trenchmobile is heavy-duty unit constructed on an all-welded arch type frame. Variable speed selections are provided for operating the bucket line, conveyor belt, travel, and digging traction. Highly mobile, the 88 has road speeds up to 12.65 mph for self powered moves between jobs.

Circle letter (M) on reply card.

(N) CHEMICAL INHIBITOR

A new chemical inhibitor for corrosion control in oil production has recently been made available by Visco Products Company, Inc. The new product is a polar type organic material, which will be marketed as Visco 953-X.

Corrosion inhibiting characteristics of Visco 953-X are attributable to its property of being absorbed on metal surfaces to form a lasting film, which is impervious to the attack of most corrosive agents. The new product is a complex synthetic composition having medium fluidity at atmospheric temperatures.

Circle letter (N) on reply card.

(O) PIPE FITTINGS

Agilene (Polyethylene) flanged pipe fittings, such as tees, crosses, 45 and 90 deg elbows, up to 6-in. nominal pipe size made throughout of Polyethylene and of fully welded construction are now available from the American Agile Corporation. Agilene welded and flanged pipe fittings are made to standard dimensions of the American Standard Class 125 cast iron flanged fittings, and can be put into existing pipe lines.

Circle letter (O) on reply card.

(P) COOLING TOWERS

J. E. Pritchard and Company has announced a new line of cooling towers known as Cotospray towers. These towers are built of Redwood wood and all bolts, nuts, washers, and nails are galvanized steel. Distribution header is of steel and nozzles are bronze-nonclogging type. Louvers are 1-in. surfaced redwood. Basins are leak-proof steel pan type (up to and including 10 ft-6 in. by 10 ft size) with redwood sideboards throughbolted to basin sills. All towers are complete with necessary accessories such as flat makeup valves, suction screen and overflow.

Circle letter (P) on reply card.

(Q) ATOM MODELS

The Fisher Scientific Company has announced availability of new atom models to enable the chemist, research worker, physicist and instructor to construct scale models of molecules and ions made up of a metal atom and innumerable combinations of other atoms. Called the "Metal-Coodination Atom Model Kit," the new set includes 87 hand-finished atom models for studies in stereo-chemistry.

Circle letter (Q) on reply card.

(R) DIESEL FUEL

Samples of a new ignition improver for diesel fuel are being made available by Ethyl Corporation for evaluation by the oil industry. Ethyl's new fuel additive, it was reported, will make it possible for refiners to improve the cetane number of middle distillates simply and economically, thereby increasing the potential output of desired grades of diesel fuel. The compound consists of a mixture of primary amyl nitrates, which is blended into the finished fuel.

Circle letter (R) on reply card.

(S) THREADING MACHINE

Outstanding feature of the new RIDGID "500" pipe and bolt threading machine which the manufacturer, The Ridge Tool Company, has announced is now ready for immediate shipment, is a new type of self-contained die head. The new Quadritype die head is instantly adjustable to thread 1 to 2-in. pipe, including over and under size, regardless of position of quick-opening lever and without removing dies or die head from the machine.

Circle letter (S) on reply card.

(T) PIPE TAPE

Dressertape, a new polyvinyl chloride pipe tape, has been announced by Dresser Manufacturing Division. This tape is said to possess exceptional dielectric and insulation properties. The

10 mil dressertape has an insulation resistance of 100,000 megohms and dielectric strength of 10,000 v. Dressertape has high adhesive firmness, extra strength, sunlight resistance, and excellent aging qualities.

Circle letter (T) on reply card.

(U) METERS

The Smith Meter Company has a new meter called the Smithway Model S meters adapted to the exacting conditions encountered in the measuring of petroleum and other liquid products. They may be used on a high speed loading rack, pipe lines to or from storage, on gathering lines, for the many refinery services, or for chemical or industrial application. The meters operate on the rotary principle.

Circle letter (U) on reply card.

Trade Literature

Publications will be sent free.

(V) CENTRIFUGAL PUMPS

Two instruction booklets covering the installation, operation, and repair of its single-stage, single-suction, and multi-stage centrifugal pumps have been released by Allis-Chalmers Manufacturing Company. The booklets recommend that regular inspection be followed and each carries a page on which the user can keep a maintenance record of his pump. Each booklet also has a handy reference table and includes a description of latest developments of various equipment. Section drawings are large for easy reference.

Circle letter (V) on reply card.

(W) SPEED REDUCERS

Western Gear Works and Pacific Gear and Tool Works have issued a 40-page bulletin describing the new Pacific-Western herringbone speed reducers, available in various types and sizes for all ordinary requirements. Housings on the reducers are of a gray cast iron, well ribbed for strength and rigidity. To lubricate the geared equipment, a splash system has been developed. The gear teeth are continuously and positively lubricated by dipping in the oil. Rotation in either direction causes a liberal supply of oil to flow through the bearings. The bulletin includes diagrams, tables, pictures, and much valuable information.

Circle letter (W) on reply card.

(X) PRICE SHEET

A new catalog containing engineering data and price sheet has been issued by Chelsea Fan and Blower Company. The catalog describes 30 fan types in more than 300 sizes. Included therein are complete specifications, dimensions, installations, diagrams, and product photographs, as well as extensive information on the proper selection and installation of fans for every industrial, commercial, and residential requirement.

Circle letter (X) on reply card.

(Y) TRANSMISSIONS

The Turner Machinery Company has published a bulletin completely describing and illustrating the new Turner multi-speed transmissions. In use with electric motors or gas engines the transmissions makes available a wide range of output speeds. Where special speeds are needed, three, six, and nine-speed transmissions are available. The transmissions are in sizes from 1 hp to 60 hp.

Circle letter (Y) on reply card.

(Z) VALVES, LUBRICANTS

A new 35-page service bulletin describing types, sizes, operation, and features of Rockwell-built Nordstrom corrosion resistant valves has been issued

by Rockwell Manufacturing Company. Special reference is also made to Nordstrom Multiport, steam jacketed and power operated valves and their varied applications in the chemical and process industries. More than 100 photographs, sectional drawings, and dimensional drawings illustrate valve sizes, types, and practical applications. A special section is devoted to Nordstrom lubricants and lubricant equipment.

Circle letter (Z) on reply card.

(AA) STEEL FLANGES

A 32-page, 2-color bulletin titled "Drop-Forged Steel Flanges," has been published by Harrisburg Steel Corporation. A table of dimensions for primary pressure ratings plus diagrams of various weights of flanges, and steel welding neck flanges is included. Also included are tables on the Harrisburg drop-forged steel van stone or lapped flanges, steel blind flanges, typical flange facings and facing dimensions, drilling templates, etc.

Circle letter (AA) on reply card.

(AB) INSTRUMENTATION

The "Fundamentals of Instrumentation for the Industries" is the title of booklet 80-2, which consists of 126 pages. As the title indicates, it covers the fundamentals of measurement, control, and transmission of variables encountered in industry. Typical applications are also discussed. The booklet is clearly illustrated containing tables, diagrams, and other clarifying data. Minneapolis-Honeywell Regulator.

Circle letter (AB) on reply card.

(AC) STEEL FACILITIES

"Allegheny Ludlum Serves the West" is a new bulletin that illustrates and describes the expanded facilities of the Allegheny Ludlum Steel Corporation on the Pacific Coast. It includes data on equipment and production (types, sizes, materials, etc.) of the company's Los Angeles forge plant; range of stock in its tool steel warehouses at Los Angeles and San Francisco; and sales and engineering representation in both of these cities and Seattle.

Circle letter (AC) on reply card.

(AD) WATER CONDITIONING

A greatly enlarged edition of the Permutit Data Book has been prepared by The Permutit Company. This data book supersedes an earlier volume produced in 1949. Brought up-to-date and completely revised, it presents a compilation of 77 tables. The subjects covered, to name a few are: Hydraulics, impurities in water, chemical conversions, saturated steam, boiler feedwater make-up requirements, chemicals used in water treatment, alkalinity relationships, specific gravities, and chemical reactions. This leatherette bound volume in the 5 by 7¼-in. size contains 116 information-packed pages.

Circle letter (AD) on reply card.

(AE) PIPE, LEAK LOCATORS

The Goldak Company has issued a reference guide on its new and improved instruments in the electronic field. Pictures and diagrams show how to use the pipe locators, valve and box locators, leak detectors. These instruments consist of self-contained transmitter units and self-contained receiver units.

Circle letter (AE) on reply card.

(AF) STEEL DURABILITY

The International Nickel Company, Inc., has published a reprint of an article "Atmospheric Durability of Steels Containing Nickel and Copper," by N. B. Pilling and W. A. Wesley. Data in the article include 8 tables and charts. Observations are based on some specimens after 22 yr. Comparisons of results are made on some specimens for moderate and heavy industrial, marine, and rural atmospheres.

Circle letter (AF) on reply card.

(AG) OILS, GREASES, WAXES

A new technical bulletin on the properties of Kel-F oils, waxes, and greases has just been issued by the chemical manufacturing division of The M. W. Kellogg Company. Stemming directly from Kellogg's development work on plasticizers for Kel-F molding powders, these new Kel-F greases, oils, and waxes are indicated to have many commercial applications. Kel-F oils have lubricating properties that are useful in applications where chemical inertness and resistance to high temperatures are important.

Circle letter (AG) on reply card.

(AH) HYDRAULIC ANCHOR

A new type hydraulic anchor has been announced by The Guiberson Corporation, and described in a one-page data sheet. The hydraulic anchor is recommended by the company for use with all Guiberson production-type packer—as a positive means of holding the packer and tubing down while the well is pressured below the packer. The anchor may even be run upside down with any effect one its operation. Case hardened piston slips in Monel inserts assure positive action and maximum corrosion resistance.

Circle letter (AH) on reply card.

(AI) OPEN CHANNEL METER

The Bristol Company has just published a bulletin describing the recently-announced Series 500 line of the company's open channel flow meters. The bulletin, No. F1606, describes the application of the instruments to the measurement of the flow of water, sewage, industrial plant effluent, irrigation water, and other liquids through weirs and flumes of all types.

Circle letter (AI) on reply card.

(AJ) MOBILE RADIO

A new brochure outlining the uses of two-way mobile radio equipment for materials handling, plant maintenance, plant protection, and other industrial applications has just been issued by the RCA engineering products department. The four-page, illustrated leaflet, entitled "Mobile Industrial Radio," provides management with important information on the two-way radio. Pamphlet No. is MC-1752.

Circle letter (AJ) on reply card.

(AK) BRIDGE INSTRUMENTS

The Bristol Company has just published a bulletin describing its line of dynamaster electronic potentiometers and bridge instruments for industrial plant, pilot plant, process, research and laboratory use. The 36-page bulletin gives information concerning a number of new electronic instruments for recording and indicating such variables as temperature, pH, speed, voltage, power, current, smoke density, thickness, strain, and a wide variety of other variables which can be measured in terms of d-c current, d-c voltage, resistance, or capacitance.

Circle letter (AK) on reply card.

(AL) GENERAL CATALOG

American Hoist and Derrick Company has published a new general catalog now available. It covers all equipment from its giant revolver cranes, through extensive line of locomotive cranes, hoists, material elevators, car pullers, right down to the Crosby wire rope clips. Also included with each catalog is a return card which enables the recipient to send for catalogs of the equipment he is especially interested in. American Hoist and Derrick.

Circle letter (AL) on reply card.

(AM) FLUID AGITATION

A new catalog, describing turbine-type Lightnin Mixers for open and closed tanks, and containing a factual discussion of fluid agitation, has just been released by the manufacturers, Mixing Equipment Company, Inc. In 32 illustrated pages, the new Lightnin Mixer catalog explains how fluid agitation results may be obtained for any process. It shows how to anticipate process changes by installing a mixer with interchangeable speeds. It describes how a standard-design mixer can be adapted to give the versatility of a custom-design unit.

Circle letter (AM) on reply card.

(AN) GAS COMPRESSOR INSTRUMENTS

A new four-page instrumentation data sheet No. 7.2-3, is now available from Minneapolis-Honeywell Regulator Company. It provides a general review of instrument applications in gas compressor stations for the purposes of (1) automatic operations with all key variables under control and (2) efficient operation with a minimum of maintenance, as well as protection against unsafe operating conditions. Applications discussed are the measurement of gas flow, pressure, and temperature; jacket cooling water temperature control; water treatment; telemetering of station variables, and combustible gas analysis.

Circle letter (AN) on reply card.

(AO) SPEED CHANGERS

The Metron Instrument Company has announced that its Data Sheet No. 7, revised in February, is now available. It describes the company's anti-backlash miniature speed changers, for applications where the backlash between high and low speed shafts must be zero or a very low value. The anti-backlash feature is obtained in each gear section by the use of 2 parallel gear trains between the high speed and low speed ends. The lower gear train in each section is a positive drive with gears rigid on the countershafts. In the upper gear train, however, the large gear is loose on its shaft but coupled to the shaft by means of the torsion spring that is wound up prior to assembly.

Circle letter (AO) on reply card.

(AP) PIPING DESIGN

The Taylor Forge and Pipe Works Company has reprinted "How to Use Schedule Numbers in Power Piping Design," by Sabine Crocker. The chart contained in the article will prove very useful to all those using piping, Taylor Forge reported, first because the information is calculated on the basis of the new formulas that have been adopted both by the ASME boiler code and the ASA code for pressure piping, and secondly because the data in this chart reflect the pipe wall tolerances. The Taylor Forge and Pipe Works Company.

Circle letter (AP) on reply card.

Speed Your Loading Racks with

EVERLASTING VALVES

EVERLASTING valves open wide to full-pipe-size flow—or close to a drop-tight seal—INSTANTLY.

Unimpeded by valve discs or other interior obstructions, these straight-through-flow valves load tank cars at maximum pipeline capacity.

The self-lapping action of the valve disc on its seat, every time an EVERLASTING valve is opened or closed, maintains the drop-tight seal during a long life. This eliminates time lost for frequent maintenance.

Write for our Bulletin today—you'll be EVERLASTING-ly glad you did!

Type No. 4000
Screwed: All sizes ¼" to 6".
(Flanged: All sizes 1" to 6".)
For pressures to 250 lb. Other types for pressures to 600 lb.

EVERLASTING VALVE CO., 49 FISK ST., JERSEY CITY 5, N. J.

Everlasting Valves

TRADEMARK "Everlasting" REG. U.S. PAT. OFF.

FOR EVERLASTING PROTECTION

Trade Literature

(AQ) PIPE CLEANING

Flexible Pipe Cleaning Company of California has issued a fully-illustrated brochure showing its various equipment. The company states that it has attempted to show in the folder some of the basic equipment used by municipalities and industry in maintaining expensive life-lines in top condition. Available in sizes from 6 to 56 in. in diameter, Flexible pressure line scrapers are pushed through mains by water pressure.

Circle letter (AQ) on reply card.

(AR) FLOW METER

A new 40-page handbook has just been published by the Fischer and Porter Company to aid in the selection and sizing of variable-area meters. This illustrated handbook contains, in condensed form, the results of 15 year's research by the F&P fluids engineering department. A complete description of variable-area meters, tubes and floats and their comparison with variable-head meters, as well as calibration prediction data have been included.

Circle letter (AR) on reply card.

(AS) LINE LOCATOR

Wilkinson Products Company has published a data sheet on its line locator. When transmitter and receiver are assembled the instrument is ready for use by one man. As the operator crosses any metal line at a right angle to its course the wanted line will register audibly and visually when the rear unit is directly over the line. Enlargements of a pipe line, such as gate valves, corporation cocks, short stubs, and special couplings are located by the assembled units.

Circle letter (AS) on reply card.

(AT) BEARINGS

Thomson Industries, Inc. has set forth the operating principles, design, advantages, and application of Nylined bearings for rotation and reciprocation in a 4-page bulletin issued recently. The Nylined bearing consists of an outer sleeve of inexpensive metal and a relatively thin lining of Nylon bearing material. The Nylon liner is retained in the outer sleeve in a manner that will permit it to expand and contract circumferentially around the inner periphery of the outer sleeve.

Circle letter (AT) on reply card.

(AU) WATER TREATMENT

A colorful new bulletin describing a complete-package water treatment unit to treat 5 to 100 gal per minute is now available. It is for field crew or small domestic supplies, boiler feed, engine cooling, or chemical, and manufacturing process. The treatment softens, clarifies, sterilizes, or removes organic matter, tastes, or odors, and provides a water equal or superior to large municipal supplies with minimum attention. INFILCO, Inc.

Circle letter (AU) on reply card.

(AV) GEAR-MOTORS

A new eight-page, two-color bulletin on fractional-horsepower gear-motors listing 61 standard models from which to choose has been announced as available from the General Electric Company. Designated as GEA-5678, the publication describes the applications for FHp gear-motors and outlines a simple method of determining correct horsepower requirements.

Circle letter (AV) on reply card.

(AW) TURBINES

The Pyle-National Company has just released six new bulletins describing the company's line of impulse type steam, gas, or air turbines for mechanical drive, which has recently been expanded for general industrial use. One of the bulletins is devoted to each of the five types of turbines available, ranging from ¼ to 120 hp, giving performance charts, construction details, etc.

Circle letter (AW) on reply card.

(AX) CLAMPS, STRAPS, COUPLINGS

The Marman Products Company, Inc., has issued an 8-page bulletin on its clamps, straps, and couplings. The bulletin is fully illustrated, with diagrams, photos, and tables. Marman Company reports that it has spent many years developing a line of standardized clamps, straps, and couplings, virtually eliminating the need for new designs.

Circle letter (AX) on reply card.

X A.P.I. PIPE COUPLINGS

All Sizes and Types for Oil Field Use

LINE PIPE COUPLINGS A.P.I.
⅛" to 12"—Seamless and Special Processed—Black or Galvanized

PLAIN TUBING COUPLINGS A.P.I.
1" to 3"—Seamless

EXTERNAL UPSET TUBING COUPLINGS A.P.I.
¾" to 3½"—Seamless

CASING COUPLINGS A.P.I.
4½" to 13⅜"—Long or Short

HYDRAULIC COUPLINGS
⅛" to 3"—Seamless

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¾" to 12"—Seamless or Spl. Processed

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⅜" to 12"—Seamless or Spl. Processed

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WHEELING MACHINE PRODUCTS COMPANY

ELM GROVE STATION — WHEELING, W. VA.

BOOKS

Viscosimetric Tables and Indexes, *by Dr. Hans Siebeneck; 96 pp., 4 tables, six illustrations; Naturwissenschaftlicher Verlag, vormals GeBrueder Borntraeger; Nikolassee/ An der Rehwiese 4, Berlin, W. Germany; DM 21 (21 German Marks).*

This useful book is of interest to all associated with mineral oils and lubrication problems; the bitumen and tar industries, and the chemical industry. In the great majority of instances involved problems of viscosity-temperature relationships for lubricating oils and products may be taken directly from the tabulated data, without the difficult and extended calculations heretofore needed. Much of these data, and many of the calculations have been simplified by this author, making for convenience for the technologists and others working in this field of lubricants and lubrication. In six parts, each phase of the viscosity-temperature subject is covered, including data on methods for calculating various relationships and constants.

The Permian Basin Oil Directory, *Fifth Annual Edition. Published by Burmass Sales Company, Midland, Texas. Price, $3.50. Pages, 362.*

The fifth annual edition of the Permian Basin Oil Directory covers various branches of the oil industry in West Texas and Southeast New Mexico. Listings carry producers and operators, drilling contractors, well service concerns, supply companies, truck and construction concerns, and pipe lines and refineries. The book is pocket size, index-tabbed, with individual listings arranged alphabetically, giving the address, telephone number of the establishment, as well as the officers and owners, wherever these are available.

Interpretation of Aeromagnetic Maps, *by V. Vacquier, N. C. Steenland, Roland G. Henderson, and Isadore Zietz. Published by the Geological Society of America, 419 West 117 Street, New York 27, N. Y. Pages, 150.*

This book presents a method of interpreting magnetic surveys which, if extensively applied, might yield new knowledge of the earth's crust and on specific problems of regional geology, such as maximum depth of sedimentation in geologic basins. This study does not cover all aspects of magnetic prospecting. It starts with the magnetic map, covering the general principles and devoting a great many pages to illustrative figures, tables, and formulae. The calculation is elementary and is given in full so as to be useful to anyone who would like to compute approximately the magnetic effect of an assumed geologic structure.

Butane-Propane Power Manual, Principles of LP-Gas Carburetion, *by Carl Abell. Published by Jenkins Publications, Inc., 198 South Alvarado Street, Los Angeles 4, California. Price, $3.50. Pages, 330.*

This little pocket-size manual gives step-by-step directions for converting gasoline engines to butane-propane carburetion. Tools needed, sales hints, basic facts of fuel and power, carburetion, conversion, service adjustments, maintenance, and trouble shooting, are subjects carried in this book. Designed for on-the-job use, the "Power Manual" has a complete reference cross-index.

Ira Rinehart's 1952 Yearbook, Vols. 1 and 2, *published by Rinehart Oil News Company, P. O. Box 1208, Dallas, Texas. Price, $15, subscribers; $25, non-subscribers.*

This thirteenth annual edition gives a general resumé of the oil industry in 1952. It includes a financial section, dealing with the rise of oil stocks in 1952, and the dividend payments during the year, as well as listing the discovery wells made in the U. S., and general information about the industry in each state. Vol. I devotes a section to the Spraberry Trend, reprinting articles from the Oil and Gas Journal about that Trend. The books are profusely illustrated with maps and general data. Vol. I is devoted to the Mid-Continent-Texas area, Vol. II to Southeastern and Rocky Mountain region.

Midland County Oil, *published by Petroleum News Corporation, Box 331, Houston, Texas. Pages, 102.*

This Five Star publication is devoted to the oil and gas resources of a single county, and therefore is more detailed than previous publications. The first of a series of "little books" on individual county petroleum resources, this begins with a map of Midland County and a general resumé of activities from 1949. A section on general geology and on historical development is given, but most of the book is taken up by individual field summaries, of which there are 26 divisions.

Industrial Heat Transfer, *by F. W. Hutchinson. Published by the Industrial Press, 148 Lafayette Street, New York 13, N. Y. Price, $6. Pages, 336.*

Solution of problems on heat transfer between industrial fluids involves the solution of complex formulae as well as time-consuming determination of viscosity, specific heat, and density of fluids. This book is designed to simplify this. The feature of the book is 128 working charts from which a direct solution of heat transfer problems can be obtained for 70 industrial fluids ranging from air and acetylene to sulfur dioxide and water. These graphs are equal in accuracy to the equations from which they are derived.

Fuel and Power in Captive Middle Europe, *by Jan Wszelaki. Published by Mid-European Studies Center, 110 West 57th Street, New York, N. Y. Price, 25 cents. Pages, 64.*

This book is an analysis of the industrial potential in the satellite area. Taking the Communist plans and proclaimed achievements for coal, lignite, coke, manufactured and natural gas, oil, synthetic fuels, and electric power, the author attempts to define the possibilities for fulfillment or non-fulfillment of the immense production goals.

Technical Publications, 1949, *published by Standard Oil Company (New Jersey), 15 West 51st Street, New York 19, N. Y. Pages, 564. Not for sale.*

The 24 articles reprinted in this fourth volume of Technical Publications are papers published in technical journals during 1949 by members of Standard Oil (New Jersey) and its affiliates. It will give the reader some idea of the diverseness of the technical problems confronting the industry. Beginning with a general article, "The Role of Oil in the Modern World," by John R. Suman, the publication follows with a list of articles under the following heads: Geology and production; manufacturing, physical chemistry, and analysis. Short biographies of the authors are given at the back of the book, as well as a list of other 1949 publications.

Mineral Forecast, 2000 A. D., *by Edward Steidle. Published by the Pennsylvania State College School of Mineral Industries, State College, Pennsylvania. Pages, 152.*

The findings described in this bulletin are part of a large research program carried on in many fields. Chapters in this book carry: Mineral realism; mineral fuels; metallic minerals; nonmetallic minerals; geology group; mineral economics; mineral extraction; and mineral policies.

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